AD-A173 367 STUDY OF POTENTIAL STANDARDIZATION OF MOTION VIDEO TELECONFERENCING SYSTEMS OPERATING AT 1544 MBPS(U) DELTA INFORMATION SYSTEMS INC HORSHAM PA NOV 85 1/1

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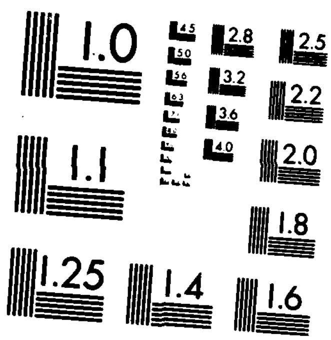


MICROCOPY RESOLUTION TEST CHART
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NCS TIB 85-7

NATIONAL COMMUNICATIONS SYSTEM

AD-A173 367

# TECHNICAL INFORMATION BULLETIN
# 85-7



# STUDY OF POTENTIAL STANDARDIZATION OF MOTION VIDEO TELECONFERENCING SYSTEMS OPERATING AT 1.544 MBPS

## NOVEMBER 1985

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

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**6b. OFFICE SYMBOL** *(If applicable)*:

**7a. NAME OF MONITORING ORGANIZATION:**

**6c. ADDRESS** *(City, State, and ZIP Code)*:
Horsham Business Center Bldg. 3
300 Welsh Road, Horsham, PA 19044

**7b. ADDRESS** *(City, State, and ZIP Code)*:

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Washington, D.C. 20305-2010

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|---|---|---|---|
| Final | FROM ______ TO ______ | November 1985 | 78 |

**16. SUPPLEMENTARY NOTATION:**

**17. COSATI CODES**

| FIELD | GROUP | SUB-GROUP |
|---|---|---|
| | | |
| | | |

**18. SUBJECT TERMS** *(Continue on reverse if necessary and identify by block number)*:
Video Teleconferencing, Full Motion Video, Teleconferencing, 1.544 Mbps, Codecs, Video Codecs

**19. ABSTRACT** *(Continue on reverse if necessary and identify by block number)*


The purpose of this effort was to study the feasibility of establishing Federal Standards for digital, color, motion codecs operating a 1.544 Mb/s for use in video teleconferencing systems.

The objective of the study was to identify and quantify, where feasible, those parameters which require standardization in order to achieve interoperability and compatibility in digital motion video transmission for teleconferencing systems.

The methodology employed in the study includes the following key elements:

1. Survey the industry to determine the manufacturers of digital, color, motion codecs operating at 1.544 Mb/s,
2. Solicit information about the codecs from the individual vendors.
3. Tabulate, study, and analyze the data received from the vendors about their products,
4. Compare key characteristics and parameters of the various codecs, and
5. Investigate existing digital, color, motion systems and compare the codec characteristics desired by the Government with those submitted by the vendors.

(Cont'd)


**20. DISTRIBUTION / AVAILABILITY OF ABSTRACT:** ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

**21. ABSTRACT SECURITY CLASSIFICATION:** Unclassified

**22a. NAME OF RESPONSIBLE INDIVIDUAL:** Dennis Bodson

**22b. TELEPHONE** *(Include Area Code)*: 202-692-2124

**22c. OFFICE SYMBOL:** NCS-TS

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SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Item #19 Abstract Cont'd:

6. Determine and study the communication channels currently available for the transmission of digital, color, motion television.

7. Coordinate with the Government and with other agencies concerned with standardization and interoperability of video codecs operating at 1.544 Mb/s.

8. Summarize the findings of the survey and the study.

# NCS TECHNICAL INFORMATION BULLETIN 85-7

STUDY OF POTENTIAL STANDARDIZATION OF
MOTION VIDEO TELECONFERENCING SYSTEMS
OPERATING AT 1.544 MBS TRANSMISSION RATES

NOVEMBER 1985

PROJECT OFFICER

DENNIS BODSON
*Senior Electronics Engineer*
Office of NCS Technology
and Standards

APPROVED FOR PUBLICATION:

for MARSHALL L. CAIN
Assistant Manager
Office of NCS Technology
and Standards

## FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile standards. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
ATTN: NCS-TS
Washington, DC 20305
(202) 692-2124

# STUDY OF POTENTIAL STANDARDIZATION OF MOTION VIDEO TELECONFERENCING SYSTEMS OPERATING AT 1.544 MBS TRANSMISSION RATES

November 27, 1985

Final Report

Submitted to:

NATIONAL COMMUNICATIONS SYSTEM

Office of Technology and Standards

Washington, DC 20305

Contracting Agency:

DEFENSE COMMUNICATIONS AGENCY

Contract Number - DCA100-83-C-0047

Modification P00004

Task Order Number 83-C-0047-84-004

Subtask 3

D E L T A  I N F O R M A T I O N  S Y S T E M S,  I N C.
Horsham Business Center, Bldg. 3
300 Welsh Road
Horsham PA 19044

STUDY OF POTENTIAL STANDARDIZATION OF DIGITAL MOTION VIDEO CODECS (1.5 MB)

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# 1.0 INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc., for the Office of Technology and Standards of the National Communications System, an organization of the U. S. Government, headed by National Communications System Assistant Manager Marshall L. Cain. Mr. Cain is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, the use of which are mandatory by all Federal agencies.

## 1.1 PURPOSE

The purpose of Subtask 3 of Task Order 84-004 performed under Modification P00004 of Contract DCA100-83-C-0047, was to study the feasibility of establishing Federal Standards for digital, color, motion codecs operating at 1.544 Mb/s for use in video teleconferencing systems.

## 1.2 OBJECTIVE

The objective of the study was to identify and quantify, where feasible, those parameters which require standardization in order to achieve interoperability and compatibility in digital motion video transmission for teleconferencing systems.

## 1.3 METHODOLOGY

The methodology employed in the study includes the following key elements.

1) Survey the industry to determine the manufacturers of digital, color, motion codecs operating at 1.544 Mb/s.

2) Solicit information about the codecs from the individual vendors.

3) Tabulate, study, and analyze the data received from the vendors about their products.

4) Compare key characteristics and parameters of the various codecs.

5) Investigate existing digital, color, motion systems and compare the codec characteristics desired by the Government with those submitted by the vendors.

6) Determine and study the communication channels currently available for the transmission of digital, color, motion television.

7) Coordinate with the Government and with other agencies concerned with standardization and interoperability of video codecs operating at 1.544 Mb/s.

8) Summarize the findings of the survey and the study.

## 1.4 SCOPE OF THE STUDY

The scope of this study includes the solicitation of information provided voluntarily by

1) codec vendors in response to a detailed questionnaire,

2) discussions with current and future users of 1.544 Mb/s digital, color, motion video teleconferencing systems,and

3) carriers supplying teleconferencing services.

Additionally, information available in the public domain was utilized.

The scope does not include the testing of motion codecs or motion teleconferencing systems, nor does it include verification of data provided by any of the above listed sources except that the final typed tabulation of data supplied by each vendor was returned to him for correction and concurrence. Further, the establishment of standards for the parameters of a motion codec is not included in the scope of this initial study.

Future efforts necessary to establish proposed standards for motion codecs are discussed in Section 4.0 of this Final Report.

## 1.5 LIMITATIONS OF THE FINAL REPORT

Several limitations were imposed upon the study due to time and funding. It is important to understand these factors in reading and assessing the information in the Final Report.

1) The effort was limited to studying only digital, color, motion codecs operating at 1.544 Mb/s. Codecs which operate at data rates other than 1.544 Mb/s are not within the scope of this report by direction. Codecs which are capable of operating at any of several selectable data rates including 1.544 Mb/s are included in the study only to the extent of presenting data and analyzing performance when the codec is operating at 1.544 Mb/s.

2) The effort was strictly limited to studying only motion digital TV codecs. Other systems used in a motion teleconferencing system such as facsimile, audio, and graphics were not included except as supplied as an integral option of the motion codec configuration and the data is transmitted as a part of the single 1.544 Mb/s data stream.

3) All data used in the various comparison tables were provided by the individual codec vendors. The vendors later concurred with the validity of data pertinent to their product as typed for the Final Report. DIS neither agrees nor disagrees with these data but presents the data in the tabular format for comparison purposes. However, conclusions are drawn and recommendations are made regarding some of the codec performance parameters and specifications.

## 1.6 DISCUSSION OF DIGITAL VIDEO CODECS

### 1.6.1 TYPES OF DIGITAL VIDEO TELECONFERENCING

There are, in general, two types of digital video teleconferencing codecs and systems in use today. The first type of digital video codec provides for the transmission of only a single frame or a single image of a television picture. This type of transmission is sometimes known as freeze frame, still frame, or slow scan TV transmission. In the freeze frame type of video teleconferencing one of the 30 TV frames per second generated by the TV camera is captured or frozen and stored in a digital memory during 1/30 second.

The stored image can be processed or compressed to reduce the time required for transmission over various narrowband data or telephone circuits. The transmission time is substantially longer than a frame interval, being dependent on the amount of compression achieved in the codec and the data rate of the communication channel. It is obvious then that motion cannot be conveyed with a freeze frame video codec since a single frame is transmitted rather than the sequence of frames necessary to depict motion information.

The second type of digital video codec provides for the transmission of real time sequences of TV frames or images in a manner which conveys motion. In some motion codecs the dimension of time (inter-frame) is utilized in conjunction with the other intra-frame dimensions of television signals for processing and compressing the image sequences to minimize the amount of data to be transmitted; ie, minimizing transmission time for a given channel data rate.

Still frame codecs are not included in this report. Motion codecs operating at 1.544 Mb/s are the sole subject of this report.

### 1.6.2 OVERVIEW OF MOTION CODEC TECHNOLOGY

Digital motion codecs have been in operational use for transmission of color television pictures since 1967 for the Department of Defense. Experimental codecs and systems were demonstrated earlier in 1964 and 1965 for the U.S. Navy and Army. The following subsections provide a brief overview of the history of motion codecs demonstrated or used in operational digital, motion, color teleconferencing systems.

### 1.6.2.1 CODEC EQUIPMENTS

Digital codes for transmitting monochrome and color television pictures were developed by various organizations including Bell Laboratories, Philco-Ford, Ball Brothers, and RCA during the 1960's. These codecs operated at bit rates ranging from 108 Mb/s for PCM coding of color television signals to 30Mb/s for Delta Modulation coding of monochrome television signals. Other coding techniques were also employed with varying degrees of success.

For nearly 10 years no new codecs were used operationally in teleconferencing systems primarily due to the high cost of the codec and the relatively high cost of the digital communication channel needed to transmit the digital bit stream. Considerable development was in progress and enhanced codecs using adaptive and inter-frame coding techniques were developed by American Electronic Labs, Digital Communications Corporation, Comsat Corporation, Nippon Electric Company, and others.

With the advent of satellite digital communications and the reduction in cost of motion codecs, several vendors have recently developed codecs for teleconferencing applications at bit rates from below 1.5 Mb/s to 20 Mb/s. Among the vendors are Compression Labs Incorporated, Nippon Electric Company, GEC-McMichael Ltd., MACOM-DCC, and American Telephone and Telegraph Company. Other Vendors such as Widergren Communications have developed codecs to operate at bit rates significantly below 1.5 Mb/s with some additional performance degradation.

It is expected that in the near future codecs will be developed to yield performance and quality equivalent to today's 1.5 Mb/s codecs while operating at 1/2 and even 1/4 of the 1.5 Mb/s data rate.

### 1.6.2.2 TELECONFERENCING SYSTEMS

As mentioned previously, digital motion TV systems were initially installed or demonstrated for evaluation by DOD agencies. In 1964 the U.S. Navy operated an experimental secure TV link which transmitted monochrome TV pictures at 30 Mb/s with a codec manufactured by Ball Brothers.

In 1965 Philco-Ford demonstrated perhaps the first inter-frame compression codec for transmitting color TV at 16 Mb/s utilizing an RCA modem over the NBC analog television network circuit in a program for the U.S. Army.

The first operationally secure digital color codec, developed by Philco-Ford, utilizing DPCM intra-frame coding was installed in a Western Union digital microwave system operating at 36.8 Mb/s for the Department of Defense in 1967. These particular codecs and the system are still in use today. Eleven years later DOD contracted the American Electronics Labs to deliver two additional codecs employing an improved adaptive DPCM compression algorithm for another secure operational color teleconferencing system which is also still in operation.

In the past 5 years other codecs have been developed and operated in systems whose bit rates range from 20 Mb/s to 1.5 Mb/s using equipments manufactured by NEC, DDC, and CLI.

The past two years has seen the installation of 1.5 / 3.0 Mb/s codecs in several digital motion teleconferencing operational systems using primarily satellite data links. Among the organizations using or providing motion teleconferencing services are Allstate Insurance, Aetna Insurance, Arco, SBS, ATT, ISACOMM, NASA, Citicorp, and American General Insurance. The list is growing rapidly. There are only two types of codecs, manufactured by CLI and NEC, employed in the above systems. Since the two codecs utilize different compression algorithms, there is no interoperability or compatibility among the motion teleconferencing systems using different vendor codecs.

## 1.7 SUMMARY OF THE REPORT

Section 2.0 of the report contains the codec vendor solicited data. The data is organized in the form of charts in which the question asked of the vendor in the questionnaire is presented in the left most column. The responses of each of the vendors are presented in subsequent columns aligned with the original question for ease of comparison.

The charts are organized so that each chart contains data related to a specific topic; eg, mechanical dimensions, motion performance, warranty, etc.

Section 3.0 contains a comparison of some of the key specification and performance parameters of the various codecs. The rationale for the questions contained in the questionnaire is provided as an aid to the reader in performing an independent comparison of the codecs and their performance. Key topics include resolution, equivalent analog performance, compression technique, bit error rate performance, and motion performance.

Section 4.0 recommends efforts which will lead toward compiling the data needed in order to develop proposed codec standards.

## 2.0 VENDOR RESPONSES TO MOTION CODEC QUESTIONNAIRE

This section contains the questions asked in the Motion Codec Questionnaire which was sent to the various motion codec manufacturers together with the responses received from them. Five vendors responded with data about a total of seven codecs: two vendors each described two codecs. The following is a summary of the vendors responding to the questionnaire and the codecs described.

| VENDOR | CODEC MODEL OR NAME |
|---|---|
| CIT ALCATEL | VISIOCODEC 2 |
| COMPRESSION LABS, INC. | VTS 1.5E |
| | REMBRANDT |
| FUJITSU AMERICA INC. | FEDIS 07/1.5 |
| GEC VIDEO SYSTEMS | GEC McMICHAEL CODEC |
| NEC | NETEC -1-IV |
| | NETEC -XI (MC) |

The questionnaire specifically stated that the study was concerned exclusively with codecs operating at 1.5 Mb/s and therefore information only about codecs operating at 1.5 Mb/s was to be provided. The subsequent tabulations and discussions contain only the 1.5 Mb/s codec data although in some cases vendors provided a complete response to the questionnaire about codecs operating at other data rates. However, requests for information about other data rate capabilities were included within the format of the questionnaire. The responses to these questions are included.

The uneditted questions appear in the first column of each of the following tables. The responses received from each of the vendors are tabulated in subsequent columns, one for each codec reported, so that the response is aligned with the question. This format facilitates comparison of the codecs for each paramenter of interest. The responses are uneditted except by the vendor who was provided with a verification copy of his portion of the initial compilation. Corrections made by the vendors have been incorporated. Therefore, the data should be valid through April, 1985. In some cases the vendors chose to expand on the response to certain questions. These additional comments are included as addenda in Section 2.6.

This section is organized in the same format as the original questionnaire. There are six sections. Various types of data are consolidated logically into these six sections as shown below.

Section 2.1; Part 1) Product Nomenclature and General Description.
Section 2.2; Part 2) Technical Specifications; Input and Output Signals.
Section 2.3; Part 3) Technical Specifications; Performance.
Section 2.4; Part 4) Physical Description and Specifications.
Section 2.5; Part 5) Other Product Data.
Section 2.6; Addenda.

Each of these sections contains several subsections further organizing the data received into functional areas. The data, in some cases, is rather lengthy and requires several pages; however, the question to response correlation is maintained.

The following abbreviations are used in the tables and graphs contained in this report to identify the codec questionnaire respondees.

| | |
|---|---|
| CLI | Compression Labs, Inc. |
| CIT | CIT Alcatel |
| GEC | GEC McMichael, Ltd. / GEC Video Systems |
| NEC | NEC America, Inc. |
| FAI | Fujitsu America, Inc. |

The additional abbreviations listed below are used to indicate vendor responses to some questions.

| | |
|---|---|
| CP | Company Proprietary |
| NA | No Answer Available or No Response |

2.1 PART 1: PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION.

This section contains basic information about the vendor, the product, pricing, and the vendor's warranty and service policies. The section is divided into six parts as follows.

2.1.1 SECTION 1: VENDOR IDENTIFICATION.
Vendor name, address, contacts, and phone numbers.

2.1.2 SECTION 2: CODEC IDENTIFICATION.
Codec name, model number, indication of degree of productization, and number of units delivered.

2.1.3 SECTION 3: PRICING INFORMATION.
Price of the codec and options, maintenance, training, and repair.

2.1.4 SECTION 4: PRODUCT LIFE.
Expected availability period, spares support period, planned improvements, and customization available.

2.1.5 SECTION 5: WARRANTY.

2.1.6 SECTION 6: SERVICE, MAINTENANCE, REPAIRS, AND TRAINING.
Availability, source, type, and lead time for field repairs, depot/factory location, type of training available, location, and duration.

PART I. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION

| I. VENDOR IDENTIFICATION | COMPRESSION LABS,INC.(VTS 1.5E) | COMPRESSION LABS,INC(REMBRANDT) | FUJITSU AMERICA,INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Company Name | Compression Labs, Inc. | Compression Labs, Inc. | Fujitsu America, Inc. | CIT Alcatel | NEC | NEC | U.K.;GEC McMICHAEL LTD<br>U.S.A;GEC Video Systems Division of English Electric. |
| B. Street Address | 2305 Bering Drive | 2305 Bering Drive | 1945 Old Gallows Road, Suite 305 | Centre de Villarceaux NOZAY | 2740 Prosperity Avenue | 2740 Prosperity Avenue | U.K.; Sefton Park, Stoke Poges<br>U.S.A.;E.E.Inc.,102 Midland Ave, Portchester, New York. |
| C. City | San Jose | San Jose | Vienna, | 91620 La Ville du bois | Fairfax | Fairfax | U.K.; Slough<br>U.S.A.; Portchester. |
| D. State | California | California | Virginia | France | Va. | Va. | U.K.; England<br>U.S.A.; New York. |
| E. Zip Code | 95131 | 95131 | 22180 | | 22031 | 22031 | U.K.; SL2 4HD<br>U.S.A.; 10573. |
| F. Contacts;Name<br>Title<br>Telephone Number<br>Contact<br>Title<br>Telephone Number | Fentress Hall<br>V.P.Marketing<br>(408) 946-3060 | Fentress Hall<br>V.P.Marketing<br>(408) 946-3060 | Kenshiro Kaniyama<br>V.P. Telecommunication Engrg.<br>(703) 356-5758. | Mr. Bertrand Teisseire<br>Ingenieur Technico Commercial<br>(6) 449.20.00 p.4018 | Dr.A.Fabris<br>Dir. of Business Network Systems<br>(703)560-2010<br>Mr. Y. Yamamura<br>Mgr. of Business Network Systems<br>(703)698-5540 | Dr.A.Fabris<br>Dir. of Business Network Systems<br>(703)560-2010<br>Mr. Y. Yamamura<br>Mgr. of Business Network Systems<br>(703)698-5540 | U.K.;Mr. Duffy<br><br>+44 2816 2777<br>U.S.A.;E.D.Daly.<br><br>(914) 937-7450 |
| G. Other Vendor Information | Company brochures were enclosed | Company brochures were enclosed | NA | | Codecs operating at lower data rates are also available. | Codecs operating at lower data rates are also available. | Also satellite comm's equipment supplier. |

TABLE 2.1-1: VENDOR IDENTIFICATION

PART 1. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION (continued)

| 2. CODEC IDENTIFICATION | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Codec Name | VTS 1.5E | Rembrandt. | FEDIS 07/1.5. | VISIOCODEC 2 | NETEC-IV. | NETEC-II (NC). | GEC McMichael Codec |
| B. Model Number | VTS 1.5E | N.A. | - | NA | NA | NA | GVS 3 |
| C. Date Introduced | May 1983 | April 1985. | - | 1984. | 1984. | 1982. | January 1984 |
| D. Are product specifications enclosed? | Yes | Yes. | No. | Yes. | Yes. | Yes. | Yes |
| E. Are application notes enclosed? | Yes | No. | No. | NNo. | NA | NA | No |
| F. Define available options which provide features not included in the subsequent specifications | | | | NA | ABS Mux, F Mux, VSP. | ABS Mux, F Mux, VSP. | |
| Option 1. | NA | NA | Encryption. | | Adaptive bit sharing multiplexer. | Adaptive bit sharing multiplexer. | Split screen encoding/decoding unit |
| Option 2. | NA | NA | | | Video system processor. | Video system processor. | Video and audio switching and mixing unit |
| Option 3. | NA | NA | | | Flexible bit rate multiplexer. | Flexible bit rate multiplexer. | System control unit (custom configurable), high quality audio coder and data port multiplexer units are included in relevant sections. |
| Option 4. | | | | | 3 types audio; 1) 3.4 kHz bandwidth (1 channel) 2) 2x3.4 kHz bandwidth (2 chan.) 3) 5 kHz bandwidth (1 channel). | 3 types audio; 1) 3.4 kHz bandwidth (1 channel) 2) 2x3.4 kHz bandwidth (2 chan.) 3) 5 kHz bandwidth (1 channel). | |
| G. Number of units installed | 100+ | Shipments start 4/85. | 6. | 40. | Proprietary. | Proprietary. | 50 units GVS 3 and compatible 1.544 Mbit/s codecs |
| H. Users, locations, contacts | List was supplied. | List was supplied. | Fujitsu Limited in Japan. | NA | Proprietary. | Proprietary. | List was supplied |
| I. Number of compatible systems installed | 100+ | 100+ (Interoperates with VTS 1.5 E). | 0. | NA | Propietary. | Propietary. | 160 total 1.544 Mbit/s and 2.048 Mbit/s codecs |
| J. Users, locations, contacts | List was supplied (same as 2H.) | List was supplied (same as 2H.) | - | NA | Propietary. | Propietary. | List was supplied |
| K. Other codec identification information | NA | NA | - | NA | NA | NA | CEPT approved. Meets CCITT Rec H 120 and H 130 Parts 1 and 2 |

TABLE 2.1-2; CODEC IDENTIFICATION

PART I. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION (continued)

| 3. PRICING INFORMATION | COMPRESSION LABS, INC. (VIS 1.5E) | COMPRESSION LABS, INC (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(HC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Price of the model described in the subsequent specs | VIS 1.5E, Full Duplex Video Teleconferencing System; $120,000 VIS 1.5E S/O, Send-Only Video Teleconferencing System; $69,000 VIS 1.5E R/O, Receive-Only Video Teleconferencing System; $67,000 (See price sheets for details) | Standard full duplex system - $85,000. Receive only or send only - $62,000. TV graphics option 368 pel - $13,000; 768 pel - $18,000. User data ports- $5,000. Continuous presence option - $7,000. Encryption option - $500. | Not available. | 300,000 FF (about). | List Prices; Model IV; $95 K. | List Prices; Model II(HC); $110 K. | 1-99500 USD, 2-4 89500 USD |
| B. Is this a published price? | Yes | Yes. | NA | No. | Yes. | Yes. | Yes |
| C. Is the published price list enclosed? | Yes | Yes. | NA | NA | No. | No. | Yes |
| D. Date of price sheet? | January 1, 1984 | April 1985. | NA | NA | NA | NA | September 1984 |
| E. Does price sheet include all models and/or options? | Yes | Yes. | NA | NA | NA | NA | Yes |
| F. Does price sheet include the the following? (If not state basis) | | | | NA | | | |
| Maintenance; Yes/No: | Yes | Yes (One year warranty). | NA | | Yes. | Yes. | Yes |
| Basis: | | | | | NA | NA | 1 year warranty followed by normal service |
| Training; Yes/No: | Yes | Yes. | NA | | Yes. | Yes. | Yes |
| Basis: | | | | | NA | NA | 1 week engr. training for board replacement |
| Repair; Yes/No | Yes | Yes. | NA | | Yes. | Yes. | Yes |
| Basis: | | | | | NA | NA | 1 year warranty board repair and replacement by GEC |
| Training; Yes/No: | Yes | Yes. | NA | | Yes. | Yes. | Yes |
| Basis: | | | | | NA | NA | 1 week traing F.O.C. to customer engineers for diagnostics and board replacement |
| G. Other pricing information | If GFE status of this product makes sense, CLI is willing to negotiate most favorable discounts. | If GFE status of this product makes sense, CLI is willing to negotiate most favorable discounts. | NA | NA | Warranty, one year. | Warranty, one year. | Included in attached document |

TABLE 2.1-3; PRICING INFORMATION

PART I. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION (continued)

| 4. PRODUCT LIFE | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(HC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Expected period during which the product will be manufactured. | Not available | Not available | 15 years. | 5 years. | Design life is 15 years. | Design life is 15 years. | 10 years |
| B. Guaranteed spares and support period. | 5 years | 5 years from last shipment date | 5 years. | NA | 15 years. | 15 years. | 20 years |
| C. Improvements/modifications; | | | | NA | | | |
| Announced; Yes/No; | Yes, | No. | Yes, | | NA | NA | Yes |
| Description; | European version. | NA | NA | | NA | NA | GVS 3 launched July 1984 |
| Planned; Yes/No; | Yes, | Yes, | Yes. | | NA | NA | Yes |
| Description; | Details proprietary. | Details proprietary. | NA | | NA | NA | Continuous development on codec including switchable data rates, tempest proofing. |
| D. Can custom configurations be provided? Yes/No; | Yes, | No. | Yes. | Yes. | Yes. | Yes. | Yes |
| Comments; | Features may be added to meet new customer requirements, but these are incorporated as standard. | Features may be added to meet new customer requirements, but these are incorporated as standard. | | | NA | NA | For specialist applications eg satellite news gathering, secure military environments, etc. |
| E. Additional comments or information about product life; | NA | NA | No. | NA | NA | NA | Low power and standard IC provide estimated life of 12 years. |

TABLE 2.1-4; PRODUCT LIFE

PART I. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION (continued)

| 5. WARRANTY | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Description of standard policy; | NA | One year on parts and labor. | NA | NA | One year. | One year. | 1 year full warranty parts and labor. |
| B. Is a written policy provided? | NA | Yes. | NA | NA | Yes. | Yes. | Yes, as part of quotation. |
| C. Is an extended warranty period available? Yes/No; Description; | NA | No. | No. | NA | Yes.<br>NA | Yes.<br>NA | Yes,<br>Preventative maintenance contract undertaken by GEC Service Dept. headquartered in New York. |

TABLE 2.1-5; WARRANTY

PART I. PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION (continued)

| 6. SERVICE, MAINTENANCE, REPAIRS, SPARES, AND TRAINING | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Is field service available? | | | | | | | |
| Yes/No; | Yes. | Yes. | Yes. | NA | Yes. | Yes. | Yes, |
| Basis; | NA | NA | | | NA | NA | Engineer call out. |
| B. Who provides the field service? | Dealer, Vendor employee. | Dealer, Vendor employee. | Vendor employee. | NA | NECAN. | NECAN. | Vendor employee. |
| C. Response time for field service? | 24 hours. | 24 hours. | NA | NA | As per customer request. | As per customer request. | Within 24 hours. |
| D. Defective card and unit level repairs; | On site, Factory. | On site, Factory. | NA | NA | | | At Factory. |
| Replacement loan; | No. | Yes. | | | Yes. | Yes. | No. |
| Describe; | NA | NA | | | Yes. | Yes. | |
| E. Factory location; | San Jose, California. | San Jose, California. | NA | NA | 2740 Prosperity Avenue, Fairfax, Va. 22031. | 2740 Prosperity Avenue, Fairfax, Va. 22031. | GEC McMichael, Sefton Park, Bells Hill, Stoke Poges, Slough, England. |
| F. Depot locations; | NA | NA | NA | NA | Ditto. | Ditto. | Slough, U.K.; Westminster, CA.; Portchester, New York. |
| G. Response time for card and unit repairs; | 7 working days. | 7 working days. | NA | NA | As per customer request. | As per customer request. | 24 hours. |
| H. Recommended spares list; | | | NA | NA | To customer as per application. | To customer as per application. | |
| Enclosed? Yes/No; | NA | NA | | | NA | NA | Yes. |
| Available? Yes/No; | Yes. | Yes. | | | Yes. | Yes. | Yes. |
| I. Type of training courses provided; | User, Maintenance, Operator. | User, Maintenance, Operator. | NA | NA | As per customer. | As per customer. | User, Maintenance, Operator, Combined operator/maintenance. |
| J. Training course location; | Factory, San Jose, California. | Factory, San Jose, California. | NA | NA | Normally NECAN location as per customer request. | Normally NECAN location as per customer request. | Customer's facility, Factory, and Offices in Portchester and MacLean. |
| K. Duration of courses? | | | NA | 1 week. | As per customer request. | As per customer request. | |
| User; | NA | NA | | | Yes. | Yes. | Variable. |
| Operator; | NA | NA | | | Yes. | Yes. | 1 week. |
| Maintenance; | NA | NA | | | Yes. | Yes. | 1 - 3 weeks. |
| Combined operator/maintenance | 3 days. | 3 days. | | | Yes. | Yes. | |
| L. Are training manuals provided | | | | | | | |
| Yes/No; | Yes. | Yes. | NA | Yes. | Yes. | Yes. | Yes. |
| M. Please include any other data relating to service, maintenance, and spares; | NA | NA | NA | NA | We can do all levels of training in house or at customer site | We can do all levels of training in house or at customer site | Factory trained personnel based at Portchester N.Y. Complete spares holding at New York and Los Angeles. |

TABLE 2.1-6: SERVICE, MAINTENANCE, REPAIRS, SPARES, AND TRAINING

## 2.2 PART 2: TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS.

This section is designed to provide detailed information about the characteristics of the video and audio signals which can be accepted by the codec, the characteristics of the output video and audio signals, the availability, number, type, and characteristics of ancillary digital signals which the codec can transmit, and the characteristics of the transmitted digital signal. The section is divided into five subsections as follows.

2.2.1 SECTION 1: VIDEO INPUT SIGNALS.
Describes the format, number, voltage, impedance of the input video signal and the switching capability, synchronization method, ancillary signals required, internal test signals provided, and VCR adaptability.

2.2.2 SECTION 2: VIDEO OUTPUT SIGNALS.
Describes the format, number, voltage, and impedance of the output video signal and the availability of internally generated test, sync, and subcarrier signals.

2.2.3 SECTION 3: AUDIO INPUT AND OUTPUT SIGNALS.
Defines the number, level, and impedance of the audio input and output signals, and the availability of mixing or switching, transmission quality specifications, type of coding used, and proportion of transmitted signal allocated to audio.

2.2.4 SECTION 4: ANCILLARY DIGITAL SIGNALS.
Defines the number, format, data rate, synchronization requirements, and the proportion of transmitted signal data rate allocated to the ancillary digital signals.

2.2.5 SECTION 5: DIGITAL VIDEO TRANSMISSION SIGNAL.
Describes the data rate, accuracy, stability, level, impedance, and compatibility with accepted standards, as well as the encoding standard.

PART 2. TECHNICAL SPECIFICATIONS; INPUT AND OUTPUT SIGNALS

| I. VIDEO INPUT SIGNALS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Codec accepts video signals in the following formats. | | | | | | | |
| R,G,B | | Option.‡ | | | | | Standard. |
| RS-170 Monochrome | | | | Standard | Standard. | Standard. | Standard. |
| RS-170 Color | Standard | | Standard. | | Standard. | Standard. | |
| RS-170A Color | | Standard. | Standard. | ‡ | Standard. | Standard. | Standard. |
| PAL 625 line, 50 Hz, color | | Option.‡ | | Standard. | Option. | | Standard with R,G,B on 2.048 Mb European standard codec, not on 1.544 Mb. codec. |
| PAL 625 line, 50 Hz, monochrome | | Option.‡ | | Standard | Option. | | Standard with R,G,B on 2.048 Mb European standard codec, not on 1.544 Mb. codec. |
| PAL 625 line, 60 Hz, color | | | | Standard | Option. | | Optional using external decoder to R,G,B. |
| PAL 625 line, 60 Hz, monochrome | | | | Standard | Option. | | Optional using external decoder to R,G,B. |
| Other, describe; | | ‡ No extra cost. Codec is ordered as either NTSC or PAL. | | SECAM 625 lines monochrome and color. | | | |
| B. Number of video inputs; | 7 | 8, optional. | 1. | 2 | 4 | 2 | NA |
| C. Is a video switch provided? Yes/No, Describe; | Yes, internal switch as option. | Yes, internal switch as option. | No. | Yes, split screen. | Yes, | Yes. | Yes, Internal selection between R,G,B and composite inputs for for each coding mode. |
| D. Details of signal voltage and impedance. | | | | | | | |
| Composite; | 1 Vp-p, 75 Ohms. | 1 Vp-p, 75 Ohms. | 1 Vp-p, 75 Ohms. | 1 Vp-p, 75 Ohms. | 1 VP-P, 75 Ohms. | 1 VP-P, 75 Ohms. | 1 Vp-p, 75 Ohms, NTSC or Mono. 100 IRE signal, 7.5 IRE pedestal 40 IRE sync. |
| Non-composite; Other, Describe; | | | | | | | 0.7 Vp-p, 75 Ohm, R,G,B. |
| E. Balanced/Unbalanced? | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Balanced. |
| F. Video Input connector type? | BNC. | BNC. | BNC. | BNC. | BNC. | BNC. | BNC Sockets. |
| G. Is a sync input required for system timing? | Yes | Yes | No. | No. | No. | No. | Internal and external sync is available. |
| H. Description of sync input; | | | NA | | NA | NA | |
| Stripped from composite input | Yes. | Yes. | | Yes. | | | Not essential. ‡ |
| Separate composite sync input | | | | | | | Not essential. ‡ |
| Separate H & V timing | | | | | | | |
| Other; | | | | | | | ‡ Selected as required, separate composite sync must be used with R,G,B inputs. |
| Voltage level, Impedance; | | | | NA | | | 0.3 to 2.0 Vp-p, 75 Ohms. |

(continued on next page)

TABLE 2.2-1: VIDEO INPUT SIGNALS

PART 2. TECHNICAL SPECIFICATIONS; INPUT AND OUTPUT SIGNALS (continued)

| I. VIDEO INPUT SIGNALS (cont'd) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| I. Is subcarrier required for system timing? Yes/No; | No | No. | No. | No. | No. | No. | No, subcarrier used only for chrominance decoding. |
| Derived from composite input; Separate subcarrier input; Other, Describe; | Yes | Yes. | | | | | Yes. |
| Voltage level, impedance; | | | | | | | 0.3 V nom., 75 Ohms, as part of NTSC composite input. |
| J. Is an internally generated video test signal provided? Yes/No, Describe; | No. | Yes. | No. | Yes, 75% color bar. | No. | Yes. | Yes, full field peak white, aids output level calibration. |
| K. Will codec accept VCR input? | Yes. | Yes. | No. | Yes. (See 'L' below) | No. | No. | Yes, with time base corrector option card. |
| L. Describe any restrictions on the video input signal; | NA | NA | To maintain a continue of video synchronization. | Synchro stability +/-2x10 exp-4. | NA | NA | Non-sync cuts in input may cause loss of stored images. |
| M. Describe any other pertinent input signal characteristics; | NA | NA | NA | NA | NA | NA | NTSC composite input operates as a monochrome input if a subcarrier burst is not present. |

PART 2. TECHNICAL SPECIFICATIONS; INPUT AND OUTPUT SIGNALS (continued)

| 2. VIDEO OUTPUT SIGNAL | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Code provides output signals with the following standards; | | | | | | | |
| R,G,B | | Standard. | | Standard. | | | Standard. |
| RS-170 monochrome | | | | | Standard. | Standard. | Standard. |
| RS-170 color | Standard | Standard. | Standard. | | Standard. | Standard. | |
| RS-170A color | | Standard if ext. ref. is used. | Standard. | Standard. | Standard. | Standard. | Standard. |
| PAL 625 line, 50 Hz, color | | Option. | | Standard. | Option. | | Standard with 2.048 Mb equipment Option with 1.544 Mb equipment. |
| PAL 625 line, 50 Hz, monochrome | | Option. | | Standard. | Option. | | As above. |
| PAL 625 line, 60 Hz, color | | | | Standard. | Option. | | Option (external PAL encoder). |
| PAL 625 line, 60 Hz, monochrome | | | | Standard. | Optlion. | | Option. |
| Other, Describe; | | | | SECAM 625 line monochrome and color. | | | Composite color outputs operate in monochrome for receiverd mono chrome data. |
| B. Number of video outputs; | 2 | 2 | 2. | 2. | 2. 3(with VSP option). | 2. | 1 composite + 2 sets of RGB (composite and 1 RGB set used full motion image or switched switched between full motion and graphics images, 1 RGB set used for continuous graphics image. |
| C. Details of signal voltage and impedance; | | | | | | | |
| Composite; | Composite, 1 Vp-p, 75 Ohms. | Composite, 1 Vp-p, 75 Ohms. | 1 Vp-p, 75 Ohms. | 1 Vp-p, 75 Ohms. | 1Vp-p, 75 Ohms. | 1Vp-p., 75 Ohms. | NTSC, 1 Vp-p, 75 Ohms, (100 IRE signal, 7.5 IRE pedestal, 40 IRE sync. |
| Non-composite; | | | | (R,G,B) 0.7 Vp-p, 75 Ohms. | | | RGB, 0.7 Vp-p, 75 Ohms. |
| Either; | | | | | | | |
| Other, Describe; | | | | | | | PAL option, 525 line 60 Hz., 1 Vp-p, 75 Ohms. |
| D. Balanced/Unbalanced; | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. | Unbalanced. |
| E. Video output connector; | BNC. | BNC. | BNC. | BNC. | BNC. | BNC. | BNC. |
| F. Is a separate sync output provided? Yes/No | No. | No. | No. | Yes. | Yes. | No. | Yes. |
| G. Describe the sync output; | | | NA | | | | |
| Composite; | Yes, 1 Vp-p, 75 Ohms | Yes, 1 Vp-p, 75 Ohms | | 1 Vp-p, 75 Ohms. | Composite. | | Yes. |
| Separate H & V; | | | | | | | |
| Other; | | | | | | | |
| Voltage level, impedance; | | | | | | | 2 Vp-p, 75 Ohms. |
| H. Is a separate subcarrier output provided? | No. | No. | NA | No. | No. | No. | No. |
| I. Is an internally generated video test signal provided? | No. | No. | No. | No. | No. | Yes. | Yes, sets all outputs to peak white, aids in output level calibration. |
| J. Describe any other video output signal characteristics | Color subcarrier is asynchronous with respect to sync. | NA | NA | | NA | NA. | Composite and 1 set of RGB outputs can be switched between ful motion and graphics images automatically, to display currently received image. |

TABLE 2.2.2: VIDEO OUTPUT SIGNALS

PART 2. TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS (continued)

| 3. AUDIO INPUTS AND OUTPUTS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Is audio capability available | Yes, standard. | Yes, standard. | Yes. | Standard. | Yes, standard. | Yes, standard. | Yes, standard with additional cost option for extra or high quality channels. |
| B. Number of audio inputs; | One | One | 1. | 1 standard plus 2 optional. | 2. | 1. | 1 standard, + 2 extra optional. |
| C. Is there an audio mixing or switching capability? Yes/No, Describe; | No. | No. | No. | No. | No. | No. | Yes, optional extra. |
| D. Number of audio channels transmitted simultaneously; | One | One | 1. | 1 to 3. | 2. | 1. | 1, 2, 3. (1 standard 2 or 3 with optional extra coders) |
| E. Connector type; | XLR | XLR | XLR Series (ITT CANON). | Sub. D 15 pin. | Receptacle XLR-3-14. | Recptacle XLR-3-14. | XLR, compatible with AIR also digital interface 15 way D-type at 64 Kb. |
| F. Input audio specifications; Signal level; | 0 dBm nominal, +12 dBm max. | 0 dBm nominal, +12 dBm max. | 0 dBm. | 0 dBm. | 0 dBm nominal. | 0 dBm nominal. | 0 dBm nominal for standard,. -3 dBm for high quality option (sine wave input). |
| Impedance; | 600 Ohms | 600 Ohms | 600 Ohms. | 600 Ohms. | 600 Ohms balanced. | 600 Ohms balanced. | 600 Ohms. |
| Dynamic range; | -20 dB to +12 dB. | -20 dB to +12 dB. | -16 ~ +11 dBm. | NA | Max. 9 dBm. | Max. 12 dBm. | -72 dBm. |
| Bandwidth; | 100 Hz - 5.5 KHz. | 100 Hz - 5.5 KHz. | 4 kHz or 7 kHz. | 300 to 3400 Hz. | 5 kHz. | 7 kHz. | 3.5 KHz to -63 dB standard, 6.8 KHz to -6 dB high quality option. |
| G. Number of audio outputs; Program channel; | 1 | 1 | 1. | 1 to 3. | 2. | 1. | 1 to 3. |
| Monitor channel; | NA | NA | 1. | | 2. | 1. | Optional, audio receiver. |
| H. Output program audio specifications; Signal level; | 0 dBm. | 0 dBm. | 0 dBm. | 0 dBm. | 0 dBm. | 0 dBm nominal. | 0 dBm nominal for standard, -3 dBm nominal for high quality option (sine wave input). |
| Impedance; | 600 Ohms. | 600 Ohms. | 600 Ohms. | 600 Ohms. | 600 Ohms. | 600 balanced. | 600 Ohms. |
| Bandwidth; | 100 Hz - 5.5 KHz. | 100 Hz - 5.5 KHz. | 4 kHz or 7 kHz. | 300 to 3400 Hz. | 5 kHz. | 7kHz. | 3.5 KHz to -6 dB standard, 6.8 KHz to -6 dB high quality option. |
| Distortion; | - 42 dB with 0 dBm 400 Hz tone. | - 42 dB with 0 dBm 400 Hz tone. | -65 dBm. | NA | Greater than 35 dB. | Greater than 35 dB. | N/A. |

(continued on next page)

TABLE 2.2-3; AUDIO INPUT AND OUTPUT SIGNALS

PART 2. TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS (continued)

| 3. AUDIO INPUTS AND OUTPUTS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| I. Method of measuring or specifying bandwidth; | 3 dB point. | 3 dB point. | 3.1 kHz or 7 kHz. | G711-CCITT. | NA | +/- 0.5 dB; 50 Hz to 5kHz., +0.5 dB, -1.0 dB; 5 kHz to 6kHz, +0.5 dB, -3 dB; 6 to 7 kHz. | Continuous sine wave at nominal signal level. |
| J. Method of measuring or specifying distortion; | Harmonic distortion at 400 Hz. | Harmonic distortion at 400 Hz. | NA | NA | NA | With 1 kHz tone at +8 dBm. | N/A. |
| K. Is an audio output monitor provided? Describe: | No. | No. | No. | No. | No. | Yes, front panel with U link. | Yes, Optional, audio receiver module for any program channel. |
| L. Audio output monitor specs; | | | NA | | | | |
| Impedance; | NA | NA | | | High. | High. | 8 Ohm. |
| Power level; | NA | NA | | | 0 dBm. | 0dBm. | 25 Watts. |
| Distortion; | NA | NA | | | | | N/A. |
| Bandwidth; | NA | NA | | | 5 kHz. | 7 kHz. | Up to 12 KHz dependant on audio coder. |
| M. Output connector type; | | | | | | | |
| Program channel; | XLR | XLR | XLR Series (ITT CANON). | Same as input connector. | Receptacle XLR-3-14. | Receptacle XLR-3-14. | XLR, also digital interface 15 way D-type. |
| Monitor channel; | NA | NA | - | | | | XLR. |
| N. Audio sampling rate; | Not applicable with CVSDM | Not applicable with CVSDM. | 8 kHz (for 4kHz BW) or 16 kHz (for 7 kHz BW). | 8 kHz. | 16 kHz. | 16 kHz. | 8 K samples/s standard, N/A for high quality. |
| O. Is the sampling rate fixed or variable? | Variable. | Variable. | Fixed. | Fixed. | Fixed. | Fixed. | Fixed. |
| P. Type of coding? | CVSDM | CVSDM. | PCM. | PCM, A-law, G711 CCITT. | | | |
| PCM, number of bits/sample; | | | 8 bit/sample (for 4 kHz BW). | | | 8. | 8 bit A-law as per CCITT REC G711 for standard coder. |
| CVSD; | Yes | Yes | | | | | |
| Other; | | | Subband ADPCM (for 7 kHz BW). | | ADPCM | | ADPCM for high quality option coders. |
| Q. Bit rate per audio channel; | 96 Kbps at 1.544 Mbps. 57 Kbps at 512 Kbps. | 96 Kbps at 1.544 Mbps. 57 Kbps at 512 Kbps. | 64 kbit/channel. | 64 KBits. | 64 kb/s. | 128 kb/s. | 64 KB/s. |
| R. Other signal characteristics; | NA. | NA. | NA | NA | NA | NA | Standard audio coder can be replaced with a high quality coder and 1 or 2 extra high quality coders can be used, giving wide bandwidth stereo capability. |

PART 2. TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS (continued)

| 4. ANCILLARY DIGITAL SIGNALS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL |
|---|---|---|---|---|
| A. Purpose of the ancillary digital channels; | Low and high speed data. | Low and high speed data. | To transmit data for use in teleconferencing. | Codec to codec information - 32 kbits, 2 x 64 kbits + 1 32 kbits for data. |
| B. Number of ancillary digital input ports; | 3 | 3 | 1. | 1 to 3. |
| C. Connector type; | DB25P, DB37P. | DB25P, DB37P. | D-SUB (ITT CANON). | Sub D 15 pins. |
| D. Input bit rates; | 1200 baud, 9.6 kbps - 448 kbps. | 1200 baud, 9.6 kbps - 448 kbps. | One of 1.2 kbps, 2.4 kbps, and 4.8 kbps. | 32 kbits/s (1) and 64 kbits/s (1 to 2). |
| E. Input signal format; RS-232C; | Yes. | Yes. | X. | |
| RS449; | Yes. | Yes. | X. | |
| RS-422; | Yes. | Yes. | | Yes. |
| CCIR V.29; | | | | |
| CCIR V.35; | | | | |
| MIL STD 188-100; | | | | |
| MIL STD 188-114; | | | | |
| Other; | | | | X21CL or J64. (G703) |
| F. Input signal type; | Asynchronous, synchronous. | Asynchronous, synchronous. | Synchronous. | Synchronous. |
| G. Is an external clock required | No. | No. | No. | No. |
| H. Number of simultaneous digital, ancillary channels; | 3 | 3 | 1. | 3. |

| 4. ANCILLARY DIGITAL SIGNALS | NEC (NETEC-IV) | NEC (NETEC-XI(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|
| A. Purpose of the ancillary digital channels; | User data port. | User data port. | General user data, facsimile data, room control signals, direct digitally coded audio signals. |
| B. Number of ancillary digital input ports; | 3 | 1. | 3 or 4 if standard audio channel disabled. |
| C. Connector type; | DB-25-S, DB-37-S. | DB-25-S. | 15 way D-type, wired to X21/X27 standard (RS-422 voltage levels) 37 way D-type and 25 way D-type for options. |
| D. Input bit rates; | 56 kb/s, 112kb/s, 224 kb/s, 2400 b/s, 4800 b/s.. | 2400 / 4800 b/s. | 1 at 32 Kb/s, 2 or 3 at 64 Kb/s standard, up to 8 at 50 to 19200 bit/s with optional multiplexer. |
| E. Input signal format; RS-232C; | Yes. | Yes. | Yes. Pair of RS-232C at 50 to 19200 bit/s with optional multiplexer module. |
| RS449; | Yes. | | Yes, at 64 Kb/s or 32 Kb/s option |
| RS-422; | Yes. | | Yes, standard. |
| CCIR V.29; | | | |
| CCIR V.35; | | | |
| MIL STD 188-100; | | | |
| MIL STD 188-114; | | | |
| Other; | | | 8xTTL at 200 bit/s each minimum per optional multiplexer module. |
| F. Input signal type; | Synchronous. | Synchronous. | Synchronous, asynchronous. Standard x21/x27 (RS-422) and RS-449 option synchronous, RS-232 and TTL options. |
| G. Is an external clock required | No. | No. | Not essential. |
| H. Number of simultaneous digital, ancillary channels; | 2. | 1. | 1x32 kb/s and 2x64 kb/s X21 or RS-449 with standard audio channel, extra 64 kb/s if standard audio channel disabled, one channel lost per extra audio channel. Each digital channel can be converted to 2xRS-232C and 8xTTL by external multiplexer module. Hence maximum of 8xRS-232C and 32xTTL if no other digital or audio channels. |

(continued on next page)

TABLE 2.2-4: ANCILLARY DIGITAL SIGNALS

PART 2. TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS (continued)

| 4. ANCILLARY DIGITAL SIGNALS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| I. Maximum combined data rate of all simultaneous ancillary digital channels; | 448 Kbps at 1.544 Mbps. | 448 Kbps at 1.544 Mbps. | 4.8 kbps. | 192 kbits. | 224 kb/s. | 4.8 kb/s. | 160 kb/s if standard audio channel is used, 224 kb/s if standard audio channel disabled. |
| J. Does the use of these 'picture' bits affect codec quality such as motion or resolution response? | Yes. | Yes. | No. | Slightly. | NA | NA | No visible effect except with large amounts of motion. |
| K. Number of ancillary digital ancillary output ports; | 3 | 3 | 1. | 1 to 3. | 3. | 1. | Same as input. |
| L. Output bit rates; | Same as 4B. | Same as 4B. | One of 1.2kbps, 2.4 kbps, and 4.8 kbps. | 32 kbits/s(1) and 64 kbits/s(2). | 56 kb/s, 112 kb/s, 224 kb/s, 2400 b/s, 4800 b/s. | 2400 / 4800 b/s. | 32 kb/s, 64 kb/s, 50 to 19200 b/s optional as for inputs. |
| M. Output signal type; | Asynchronous, synchronous. | Asynchronous, synchronous. | Synchronous. | Synchronous. | Synchronous. | Synchronous. | Synchronous, Asynchronous Standard X21/X27 (RS-422) and RS- 449 option synchronous, RS-232C and TTL options. |
| N. Is an output clock provided? | No. | No. | Yes. | Yes. | Yes. | Yes. | Yes, 32 kb/s or 64 kb/s plus byte timing for X21/X27 (RS-422) and RS-449 only. |
| O. Bit rate / clock stability; | 1 x 10 exp -5 | 1 x 10 exp -5 | +/- 30 ppm. | +/- 50x10 exp-6. | NA | NA | X21/X27 (RS-422) and RS-449 derived from 1.544 MHz. channel clock, RS-232C clocks from crystal oscillator. |
| P. Bit rate / clock accuracy; | +/- 1 % | +/- 1 % | ditto. | +/- 50x10 exp-6. | NA | NA | +/- 50 ppm for X21/X27 (RS-422) and RS-449, +/- 100 ppm for RS-232C. |
| Q. Output connector type; | DB 25P, DB 37P. | DB 25P, DB 37P. | D-SUB (ITT CANON). | Sub D 15 pins. | DB-25-S, DC-37-S. | DB-25-S. | Standard X21/X27 is 15 way D-type, RS-449 option is 37 way D-type, RS-232C is 25 way D-type |
| R. Do ancillary digital channels utilize bits otherwise allocated to picture transmission? | Yes (RS-449 ports). | Yes (RS-449 ports). | Yes. | Yes. | NA | NA | Yes, except for 1x64 kb/s channel normally used for standard audio channel. |
| S. Number of transmission bits allocated to each ancillary digital channel; | Depends on the bit rate. | Depends on the bit rate. | NA | 4 or 8 bits per frame. | NA | NA | 1x8 bit time slot, only used in alternate frames for 32 kb/s channel. |

PART 2. TECHNICAL SPECIFICATIONS: INPUT AND OUTPUT SIGNALS (continued)

| 5. DIGITAL VIDEO TRANSMISSION SIGNAL | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Precise data rate; | 1.544 Mbps - 512 Kbps. | 1.544 Mbps - 384 Kbps. | 1.544 M bits per second. | 1544 kbits/s. | NA | NA | 1,544,000 b/s. |
| B. Transmitted data rate accuracy; | 10 exp -5. | 10 exp -5. | +/- 30 ppm. | +/- 50x10 exp-6. | NA | NA | +/- 50 ppm (as per G703) |
| C. Transmitted data rate stability; | 10 exp -5. | 10 exp -5. | ditto. | +/- 50x10 exp-6. | NA | NA | Less than 0.1 UI jitter output. (can be loop timed from received data.) |
| D. Required receive data rate accuracy; | +/- 5 %. | +/- 5 %. | +/- 50 ppm. | +/- 50x10 exp-6. | NA | NA | Exceeds G703. (typically operates correctly at +/- 150 ppm.) |
| E. Required receive data rate stability; | +/- 5 %. | +/- 5 %. | ditto. | +/- 50x10 exp-6. | NA | NA | Jitter tolerance exceeds Bell Specification PUB 61511. |
| F. Bell DS-1 Crossconnect compatibility; | Yes. | Yes. | Yes. | | Yes. | Yes. | Yes |
| ATT Compatibility Bulletin No. 119: | Yes. | Yes. | Yes. | | Yes. | Yes. | |
| CCITT Recommendation G.703; | Yes. | Yes. | Yes. | Yes. | Yes. | Yes. | Yes. |
| G. CCIR Crossconnect compatibility; | NA | NA | Yes. | | Yes. | Yes. | NA |
| H. Transmit signal level; | 3 Vp-p. | 3 Vp-p. | In accordance with CCITT Rec G703 Part 2. | 1 V. | NA | NA | As per G703, 3V pulse nominal. |
| I. Receive signal level; | 3 Vp-p. | 3 Vp-p. | ditto. | 1 V. | NA | NA | Exceeds G703, codec typically operates with signal 20 dB below nominal. |
| J. Impedance; | 100 Ohms. | 100 Ohms. | 100 Ohms. | 120 Ohms. | 110 Ohms. | 110 Ohms. | 100 Ohms. |
| K. Signal Format; | Bipolar. | Bipolar. | Bipolar. | Bipolar. | Bipolar/NRZ. | Bipolar/NRZ. | Bipolar. |
| L. Encoding (B3ZS, etc.); | NA | NA | AMI, B8ZS. | AMI or B8ZS. | AMI/B8ZS/HDB3. | AMI. | AMI or B8ZS. ( Transmit=selectable, Receive=either) |
| M. Maximum number of like successive symbols (1 or 0); | 15 | 15 | 7 (0). | 15 (AMI). | 15. | 15. | 1=unlimited. 0=15. |
| N. Other transmission rates standard for this codec; | 896 Kbps, 768 Kbps. | NA | 0.768 Mb/s. | Yes. | 768 kb/s, 512 kb/s. 512 kb/s-2.048 mb/s. | 1.544 x 2 mb/s. | 0.772 mb/s. See Addendum GEC 01. |
| O. Does codec output digital signal comply with new CCITT H.130 Recommendation on frame structure? | No. | No. | No. | Yes. | Yes. | NA | Yes. |
| P. Explain how codec complies with CCITT H.130 Rec.? | NA | NA | No. | | Part 3. | NA | Codec implements part 2 in all respects when communicating with a 625 line 2.048 mb/s codec, which fully implements part 1. The codec also implements H120 part 3, as currently under study, during intra-regional 525 line to 525 line communication. |

TABLE 2.2.5: DIGITAL VIDEO TRANSMISSION SIGNAL

## 2.3 PART 3: TECHNICAL SPECIFICATIONS: PERFORMANCE.

Performance is defined for a static image and an image containing motion, both in an error free channel and in a channel with various levels of bit error rate. The sampling format, transmission format, and display format are defined. Conventional video transmission parameters as measured by the vendor are tabulated. Most of the questions were asked in more than one way so that the responses can be interpreted accurately. The section is divided into five parts as follows.

### 2.3.1 SECTION 1: PERFORMANCE WITH STATIC VIDEO INPUT.

Describes the specific sampling, transmission, and display format, displayed resolution, and measured performance.

### 2.3.2 SECTION 2: PERFORMANCE WITH MOTION VIDEO INPUT.

Defines the specific sampling, transmission, and display format, displayed resolution, and measured performance in the static and in the motion portion of the display. Performance degradation is described as a function of the amount of motion in the picture.

### 2.3.3 SECTION 3: BIT ERROR RATE PERFORMANCE.

Indicates the degree and type of picture degradation as the bit error rate is varied from 10 exp(-6) to 10 exp(-3).

### 2.3.4 Section 4: Compression Technique.

Describes the type of compression used, compression ratio achieved, other data rate reduction techniques employed, and compatibility with CCIR H.120 REC.

### 2.3.5 Section 5: Audio Performance.

Tabulates the performance parameters as measured and reported by the vendor. These include bit rate, sampling rate, encoding precision, and performance with various levels of channel bit error rate.

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE

| 1. PERFORMANCE WITH STATIC VIDEO INPUT (Not TV graphics input port/function) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Input video sampling format; | | | | | | | |
| No. of fields/second; | 60. | 60. | 60. | 60 | 60. | 60. | 59.94 |
| No. of frames/second: | 30. | 30. | 30. | 30 | 30. | 30. | 29.97 NTSC standard, sampling, field rate equals input field rate. |
| No. of lines/field; | 263. | 263. | 263. | 525/2 | 262. | 262. | 262 1/2 |
| No. of lines/frame; | 525. | 525. | 525. | 525 | 525. | 525. | 525 (including field blanking lines) |
| B. Video transmission format; | | | | | | | |
| No. of fields/second; | 30 | 30 | 60. | 60 | 60. | 60. | 59.4 average. |
| No. of frames/second: | 15 | 15 | 30. | 30 | 30. | 30. | 29.7 average. |
| No. of lines/field; | 240 | 240 | 259. | 143 active. | 256. | 262. | 143. |
| No. of lines/frame; | 480 | 480 | 518. | 286 active. | 512. | 525. | 286. Transmitted lines are derived by interpolation from the whole of the active video field. |
| C. Output display format; | | | | | | | |
| Display field rate; | | | | | | | |
| Luminance; | 60 | 60 | 60. | 60. | 60. | 60. | 59.94 |
| Chrominance; | 60 | 60 | 60. | 60. | 60. | 60. | 59.94 |
| Display frame rate; | | | | | | | |
| Luminance; | 15 | 15 | 30. | 30. | 30. | 30. | 29.97 |
| Chrominance; | 15 | 15 | 30. | 30. | 30. | 30. | 29.97 |
| Displayed lines/field; | | | | | | | |
| Luminance; | 263. | 263. | 263. | 525/2. | 262. | 262. | 238.5/262.5 (non-blank/total) |
| Chrominance: | 263. | 263. | 131. | 525/2. | 262. | 262. | 238.5/262.5 (non-blank/total) |
| Displayed lines/frame; | | | | | | | |
| Luminance; | 525. | 525. | 525. | 525. | 525. | 525. | 477/525 (non-blank/total) |
| Chrominance; | 525. | 525. | 263. | 525. | 525. | 525. | 477/525 (non-blank/total) |
| Interlace, Yes/No; | Yes | Yes | Yes. | Yes. | Yes. | Yes. | Yes, 525 line NTSC standard. |
| D. Do any of the above change with motion pictures? | | | | | | | |
| Input sampling format, Yes/No; | No. | No. | No. | Yes. | No. | No. | No. |
| Transmission format, Yes/No; | No. | No. | No. | Yes. | No. | No. | Yes. |
| Output display format, Yes/No; | No. | No. | Yes. | No. | No. | No. | No. |
| Describe in detail; | NA | NA | NA | NA | | NA | With large amounts of movement, adaptive field subsampling reduces the transmission field rate down to a minimum of half the normal rate. See ADD. GEC #2. |

(continued on next page)

TABLE 2.3-1; PERFORMANCE WITH STATIC VIDEO INPUT

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE (continued)

| I. PERFORMANCE WITH STATIC VIDEO INPUT (Not TV graphics input port/function) (cont'd) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(HC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| E. Horizontal sampling rate; | 7.16 x 10 exp 6 sample/second. | 7.16 M sample/second. | 910 samples/second. | 5.034 M samples/sec. | 7.2 mb/s. | 7.2 mb/s. | 5.04 million samples/s for luminance, 1.008 million samples/s for chrominance components. |
| F. Horizontal pixels in an active line interval; | 368 luminance. | 368 luminance. | 910 horizontal pixels. | 256 luminance and 52 chrominance | 384 horizontal pixels. | 384 horizontal pixels. | 256 luminance + 51 chrominance. |
| G. Displayed horizontal resolution (test chart); | 2.7 MHz Bandwidth. | 2.7 MHz Bandwidth. | 518 TV lines. | NA | 384 TV lines. | 384 TV lines. | 250 TV lines. |
| H. Vertical sampling rate; | (NTSC) | (NTSC) | NA | | 525 line. | 525 line. | Luminance 525 line/frame, chrominance components 262.5 lines/frame each. |
| I. Vertical pixels in active picture area; | 480. | 480. | 518 vertical pixels. | 286 vertical pixels. | 480 | 480 | 286 |
| J. Displayed vertical resolution (test chart); | 384 TV lines. | 384 TV lines. | NA | NA | 480 TV lines. | 480 TV lines. | 300 TV lines. |
| K. Timing basis for sampling pattern; | | | | | NA | NA | |
| Sync; | NA | NA | Yes. | Yes. | | | Yes. |
| Subcarrier; | NA | NA | | | | | |
| Other; | NA | NA | | | | | |
| L. Luminance sampling rate; | 7.16 MHz. | 7.16 M. | 7.16 M samples/second. | 5.034 M samples/sec. | 7.2 mHz. | 7.2 mHz. | 5.04 MHz. |
| M. Luminance samples per active line interval; | 368. | 368. | 455. | 256. | 384 | 384 | 256 |
| N. Chrominance channels, number; | 2, | 2. | 2. | 2. | 2. | 2. | 2 |
| R-Y, B-Y; | Yes. | Yes. | | Yes. | Yes. | | |
| I,Q; | | | | | | | |
| U,V; | | | | | | | Yes. |
| R,G,B; | | | | | | | |
| Other; | | | C1, C2, (orthogonal component). | | | C1, C2. | |
| O. Chrominance sampling rate; | | | | | | | |
| Channel 1; | 7.16/4 x 10 exp 6 samples/second | 7.16M/4 | 1.2 mHz. | 1.007 MHz. | 1.2 mHz. | 1.2 mHz. | 1.008 MHz. |
| Channel 2; | 7.16/4 x 10 exp 6 samples/second | 7.16M/4 | 1.2 mHz. | 1.007 MHz. | 1.2 mHz. | 1.2 mHz. | 1.008 MHz. |
| Other; | | | | | | | |
| P. Chrominance samples per active line interval; | | | | | | | |
| Channel 1; | 92 | 92 | 63. | 52. | 64. | 64. | 51 |
| Channel 2; | 92 | 92 | 63. | 52. | 64. | 64. | 51 |
| Other; | | | | | | | |

(continued on next page)

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE (continued)

| 1. PERFORMANCE WITH STATIC VIDEO INPUT (Not TV graphics input port/function) (cont'd) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| Q. Precision of luminance digitization; | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. |
| R. Luminance precision through transmitter and receiver including coding effects: | (Not specified). | (Not specified). | 7~8 bits / sample. | NA | NA | NA | 8 bits/sample, stationary test patterns, transmitted as systematic PCM updates. |
| Define measurement technique; | NA | NA | - | H120 CCIR Recommendation. | NA | NA | |
| S. Precision of chrominance digitization; | | | | | | | |
| Channel 1; | 6 bit | 8 bit. | 8 bit. | 8 bits/sample. | 8. | 8. | 6 bit. |
| Channel 2; | 6 bit | 8 bit. | 8 bit. | 8 bits/sample. | 8. | 8. | 6 bit. |
| T. Chrominance precision through transmitter and receiver including coding effects; | | | | | | | |
| Channel 1; | 6 bit | 8 bit. | 7~8 bit. | NA | 8. | 8. | 6 bit. |
| Channel 2; | 6 bit | 8 bit. | 7~8 bit. | NA | 8. | 8. | 6 bit. |
| Define measurement technique; | NA | NA | - | H120 CCIR Recommendation. | NA | NA | As for luminance. |
| U. Measured output signal frequency response; | | (not available) | | | | | |
| Luminance; | 2.7 MHz. | 2.7 MHz. | NA | NA | NA | NA | 2.5 MHz -3dB. |
| Chrominance channel 1; | 650 KHz, | 650 KHz, | NA | NA | NA | NA | Not available for direct measurement, 0.5MHz -3dB theoretical |
| Chrominance channel 2; | 650 KHz, | 650 KHz, | NA | NA | NA | NA | |
| Other; | | | | | | | |
| V. Measured performance; | | | | | | | |
| a) Luminance-chrominance gain inequality; | 0.5 dB. | 0.5 dB, | NA | NA | 14 IRE. | 14 IRE. | 0 dB. |
| b) Luminance-chrominance delay inequality; | 100 ns. | 100 ns. | NA | NA | +/- 54 ns. | +/- 54 ns. | (100 ns. |
| c) Short time waveform distortion; | 3 %. | 3 %. | NA | NA | Less than 14 IRE | Less than 14 IRE | None. |
| d) Signal-to-quantizing noise ratio; | 50 dB. | 50 dB. | NA | NA | More than 50 dB. | More than 50 dB. | )45 dB peak signal to rms noise. |
| Describe measurement technique; | Weighted with 4.2 MHz LPF and 3.58 Notch. | Weighted with 4.2 MHz LPF and 3.58 Notch. | NA | NA | Rhode Schwartz. | Rhode Schwartz. | On 20 IRE flat grey level, composite input and output. |
| e) Differential gain; | 6 %. | 6 %. | ( 7%. | NA | 8%. | 8%. | N/A. |
| f) Differential phase; | 6 degrees. | 6 degrees. | ( 4 degrees. | NA | 4 degrees. | 4 degrees. | N/A. |
| g) Field time waveform distortion; | 3 %. | 3 %. | ( 3%. | NA | 3 IRE. | 3 IRE. | None. |
| h) Line time waveform distortion; | 3 %. | 3 %. | ( 3%. | NA | 2 IRE. | 2 IRE. | None. |
| W. Other performance specifications; | NA | Principal difference from VTS-1.5E is higher resolution of graphics, improved motion picture quality plus operation at rates down to 384 Kbps. | - | NA | NA | NA | NA. |

PART 3. TECHNICAL SPECIFICATIONS; PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(MCI)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Input video sampling format; | All parameters same as static video. | All parameters same as static video. | | | | | |
| No. of fields/second; | | | 60 | 60. | 60. | 60. | 59.94 |
| No. of frames/second: | | | 30 | 30. | 30. | 30. | 29.97 |
| No. of lines/field; | | | 263 | 525/2. | 262. | 262. | 262 1/2 |
| No. of lines/frame; | | | 525. | 525. | 525. | 525. | 525 |
| B. Video transmission format; | | | | | | | |
| No. of fields/second; | | | 60. | 60. | 60. | 60. | 59.4 average. |
| No. of frames/second: | | | 30. | 30. | 30. | 30. | 29.7 average. |
| No. of lines/field; | | | 259. | 143 active. | 262. | 262. | 143 |
| No. of lines/frame; | | | 518. | 286 active. | 525. | 525. | 286 (See Pt.3, Sect.1, B and D) |
| C. Output display format; | | | | | | | |
| Display field rate; | | | | | | | |
| Luminance; | | | 60. | 60. | 60. | 60. | 59.94 |
| Chrominance; | | | 60. | 60. | 60. | 60. | 59.94 |
| Display frame rate; | | | | | | | |
| Luminance; | | | 30. | 30. | 30. | 30. | 29.97 |
| Chrominance; | | | 30. | 30. | 30. | 30. | 29.97 |
| Interlace, Yes/No; | | | Yes. | Yes. | Yes. | Yes. | Yes. |
| D. Do any of the above change with motion pictures? | | | | | | | |
| Input sampling format, Yes/No; | | | Yes. | Yes. | No. | No. | No. |
| Transmission format, Yes/No; | | | No. | Yes. | No. | No. | Yes. |
| Output display format, Yes/No; | | | Yes. | No. | No. | No. | No. |
| Describe in detail; | | | NA | NA | NA | NA | See Pt.3, Sect.1, B above. |
| E. Horizontal sampling rate; | | | 7.16 Msamples/second. | 5.034 Msamples/second. | 7.2 MHz. | 7.2 MHz. | Same as Pt.3 Sect.1 E. |
| F. Horizontal pixels in an active line interval; | | | 385 for luminance, 63 for chrominance. | 256 luminance and 52 chrominance | 384 horizontal pixels. | 384 horizontal pixels. | Same as Pt.3, Sect.1 F. |
| G. Displayed horizontal resolution (test chart); | | | NA | NA | 384 TV lines. | 384 TV lines. | 250 TV lines, reduced due to adaptive element subsampling with large amounts of movement. |
| H. Vertical sampling rate; | | | 525 lines/frame. | NA | 525 line. | 525 line. | Same as Pt.3, Sect.1, H. |
| I. Vertical pixels in active picture area; | | | 518 vertical pixels. | 286. | 480 | 480. | 286 |
| J. Displayed vertical resolution (test chart); | | | NA | NA | 480 TV lines. | 480 TV lines. | 300 TV lines, reduced due to adaptive element subsampling with large amounts of movement. |
| K. Timing basis for sampling pattern; | | | | | | | |
| Sync; | | | | Yes. | NA | NA | Yes. |
| Subcarrier; | | | | | | | |
| Other; | | | Separated sync from input video. | | | | |

(Continued)

TABLE 2 3-2: PERFORMANCE WITH MOTION VIDEO INPUT

PART 3. TECHNICAL SPECIFICATIONS; PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT (Continued) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| L. Luminance sampling rate; | | | 7.16 Msamples/second. | 5.034 Msamples/second. | 7.2 MHz. | 7.2 MHz. | 5.04 MHz. |
| M. Luminance samples per active line interval; | | | 385. | 256. | 384. | 384. | 256 |
| N. Chrominance channels, number; | | | 2. | 2. | 2. | 2. | 2 |
| R-Y, B-Y; | | | | Yes. | Yes. | | |
| I,Q; | | | | | | | |
| U,V; | | | | | Yes. | | Yes. |
| R,G,B; | | | | | | | |
| Other; | | | C1,C2 (orthogonal components) | | | C1, C2. | |
| O. Chrominance sampling rate; | | | | | | | |
| Channel 1; | | | 1.2 MHz. | 1.007 MHz. | 1.2 mHz. | 1.2 mHz. | 1.008 MHz. |
| Channel 2; | | | 1.2 MHz. | 1.007 MHz. | 1.2 mHz. | 1.2 mHz. | 1.008 MHz. |
| Other; | | | | | | | |
| P. Chrominace samples per active line interval; | | | | | | | |
| Channel 1; | | | 63. | 52. | 64. | 64. | 51 |
| Channel 2; | | | 63. | 52. | 64. | 64. | 51 |
| Other; | | | | | | | |
| Q. Precision of luminance digitization; | | | 8 bits per sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. | 8 bits/sample. |
| R. Luminance precision through transmitter and receiver including coding effects; | | | 7*8 bits per sample. | NA | NA | NA | 5 to 8 bits, depending on amount of movement and magnitude of change between consecutive video frames for moving elements. 8 bit for stationary elements. |
| Define measurement technique; | | | NA | H120 CCIR Recommendation. | NA | NA | Theoretical analysis and simulation subjective assessment. |
| S. Precision of chrominance digitization; | | | | | | | |
| Channel 1; | | | 8. | 8 bits/sample. | 8. | 8. | 6 bit. |
| Channel 2; | | | 8. | 8 bits/sample. | 8. | 8. | 6 bit. |
| T. Chrominance precision through transmitter and receiver including coding effects; | | | | | | | |
| Channel 1; | | | 7*8. | NA | 8. | 8. | 5 to 6 bit |
| Channel 2; | | | 7*8. | NA | 8. | 8. | 5 to 6 bit. 5 to 6 bit per channel for moving elements, depending on amount of movement and magnitude of change between consecutive video frames, 6 bit for stationary elements. |
| Define measurement technique; | | | NA | H120 CCIR Recommendation. | NA | NA | Theoretical analysis and simulations, subjective assessment. |
| U. Measured output signal frequency response; | | | NA | | NA | NA | |
| Luminance; | | | | NA | | | As for Pt.3, Sect.1, U. |
| Chrominance channel 1; | | | | NA | | | As for Pt.3, Sect.1, U. |
| Chrominance channel 2; | | | | NA | | | As for Pt.3, Sect.1, U. |
| Other; | | | | | | | |

(Continued next page)

PART 3. TECHNICAL SPECIFICATIONS; PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT (Continued) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| V. Measured performance; | | | | | | | |
| a) Luminance-chrominance gain inequality; | | | NA | NA | 14 IRE. | 14 IRE. | 0 dB. |
| b) Luminance-chrominance delay inequality; | | | NA | NA | +/- 54 ns. | +/- 54 ns. | (100 ns. |
| c) Short time waveform distortion; | | | NA | NA | Less than 14 IRE. | Less than 14 IRE. | None |
| d) Signal-to-quantizing noise ratio; | | | NA | NA | More than 50 dB. | More than 50 dB. | )45 dB. |
| Describe measurement technique; | | | NA | NA | Rhode Schwartz. | Rhode Schwartz. | As for Pt.3, Sect.I,V. |
| e) Differential gain; | | | (7%. | NA | 8%. | 8%. | N/A. |
| f) Differential phase; | | | (4 degrees. | NA | 4 degrees. | 4 degrees. | N/A. |
| g) Field time waveform distortion; | | | (3%. | NA | 3 IRE. | 3 IRE. | None. |
| h) Line time waveform distortion; | | | (3%. | NA | 2 IRE. | 2 IRE. | None. |
| W. Time required for a display of a transmitted full field blue pattern to become completely yellow when the input is switched from blue to yellow; | (Not available) | (Not available) | 100 ms. | NA | 1/30 second. | 1/30 second. | 0.13 seconds. (4 frames to within 5% of correct final levels, all parts of image change together by about 1/3 of the required change during the first x frames. |
| X. Other performance specifications; | | | NA | NA | NA | NA | NA |
| Y. Motion performance evaluation | | | | | | | |
| a) Condition 1. Up to 10% of the pixels change between frames; | | | | NA | | | |
| 1) Is motion degradation perceptible, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| Describe; | NA | NA | NA | NA | | | |
| 2) Are artifacts perceptible in the picture? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| 3) Is flicker perceptible? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| 4) Is distortion perceptible in moving objects? Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| 5) Is color degradation perceptible? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | NA | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | NA | No. | Yes. | No. |
| 6) Is resolution degradation perceptible? | | | | | | | |
| Motion area; | No. | No. | No. | NA | No. | No. | No. |
| Static area; | No. | No. | No. | NA | No. | No. | No. |
| 7) Describe any other effects resulting from changes in picture content; | NA | NA | NA | NA | NA | NA | None. |

(Continued)

PART 3. TECHNICAL SPECIFICATIONS; PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT (Continued) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| b) Condition 2. Up to 25% of the pixels change between frames; | | | | | | | |
| 1) Is motion degradation perceptible, Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | No. | No. |
| Describe; | Pixel blocking artifacts are slightly visible. | Pixel blocking artifacts are slightly visible. | Jerkiness from multi-field subsampling method. | Depending on the content of the moving picture. | | | |
| 2) Are artifacts perceptible in the picture? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | No. | Yes. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 3) Is flicker perceptible? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | Yes. | No. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 4) Is distortion perceptible in moving objects? Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 5) Is color degradation perceptible? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 6) Is resolution degradation perceptible? | | | | | | | |
| Motion area; | Yes. | Yes. | Yes. | Yes. | No. | No. | No. |
| Static area: | No. | No. | No. | No. | No. | No. | No. |
| 7) Describe any other effects resulting from changes in picture content; | NA | NA | NA | NA | NA | NA | None. |
| c) Condition 3. Up to 50% of the pixels change between frames; | | | | | | | |
| 1) Is motion degradation perceptible, Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | No. | No. |
| Describe; | Blocking artifacts residual trail. | Blocking artifacts residual trail. | Jerkiness from multi-field subsampling method. | Depending on the content of the moving picture. | NA | NA | |
| 2) Are artifacts perceptible in the picture? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | No. | Yes. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | Yes. | No. | No. | No. |
| 3) Is flicker perceptible? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | No. | No. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 4) Is distortion perceptible in moving objects? Yes/No; | No. | No. | Yes. | No. | No. | No. | No. |
| 5) Is color degradation perceptible? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| Static area, Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 6) Is resolution degradation perceptible? | | | | | | | |
| Motion area; | Yes. | Yes. | Yes. | Yes. | No. | Yes. | Yes. Adaptive element subsampling causes horiz. resolution loss to a min. of half of static res. |
| Static area: | No. | No. | No. | Yes. | No. | Yes. | No. |
| 7) Describe any other effects resulting from changes in picture content; | NA | NA | NA | NA | NA | NA | None. |

(Continued)

PART 3. TECHNICAL SPECIFICATIONS; PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT (Continued) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| d) Condition 4. Up to 100% of the pixels change between frames; | | | | | | | |
| 1) Is motion degradation perceptible, Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | Yes. | No. |
| Describe; | Blocking artifacts residual trail. | Blocking artifacts residual trail. | NA | Depending on the content of the moving picture. | NA | NA | |
| 2) Are artifacts perceptible in the picture? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | Yes. | No. |
| Static area, Yes/No; | (N/A for 100%) | (N/A for 100%) | No. | Yes. | No. | Yes. | No. |
| 3) Is flicker perceptible? | | | | | | | |
| Motion area, Yes/No; | Yes. | Yes. | Yes. | No. | No. | Yes. | No. |
| Static area, Yes/No; | NA | NA | No. | No. | No. | Yes. | No. |
| 4) Is distortion perceptible in moving objects? Yes/No; | No. | No. | Yes. | Yes. | No. | Yes. | Yes. Moving objects in about 40% of image show horiz. streaking. |
| 5) Is color degradation perceptible? | | | | | | | |
| Motion area, Yes/No; | No. | No. | No. | Yes. | No. | Yes. | Yes. (See c.6. above) |
| Static area, Yes/No; | | | No. | No. | No. | Yes. | No. |
| 6) Is resolution degradation perceptible? | | | | | | | |
| Motion area; | Yes. | Yes. | Yes. | Yes. | No. | Yes. | Yes. (See c.6. above) |
| Static area: | | | No. | Yes. | No. | No. | No. |
| 7) Describe any other effects resulting from changes in picture content; | NA | NA | NA | NA | NA | NA | None. See Addendum GEC #3. |

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE (Continued)

| 2. PERFORMANCE WITH MOTION VIDEO INPUT (Continued) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (Rembrandt) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| V. Motion performance evaluation (Continued) | All parameters same as static video. | | | | | NA | |
| e) Panning, zooming, change of video source; | | | | | | | |
| 1) Describe the visual effects when the camera is zoomed. | | | | | | | |
| Slowly (10% size variation per second) ; | Negligible. | Negligible. | No Change. | No effect. | None. | NA | No perceptible effects on normal images, changing picture element handled by normal methods. |
| Rapidly (50% size variation per second ; | Blocking artifacts; | Blocking artifacts; | The motion has any jerkiness by using multi-field subsampling. | Distortion perceptible. | None. | NA | Resolution degradation in motion areas only, where the adaptive algorithm will not cause objectionable effects. Image if it is highly detailed. As the codec is optimized for operation in a normal teleconferencing scene, its normal excellent performance cannot be maintained in a continuous zoom or pan, The codec will recover a normal full quality image within 0.5 second of the pan or zoom ending. |
| 2) Describe the visual effects when the camera is panned. | | | | | | | |
| Slowly (10% size variation per second) ; | Frame subsampling jitter. | Frame subsampling jitter. | No change. | Distortion perceptible. | None. | NA | No perceptible effects on normal images, changing picture elements handled by normal methods. |
| Rapidly (50% size variation per second ; | Blocking artifacts. | Blocking artifacts. | The motion has any jerkiness by using multi-field subsampling. | Important distortion. | No. | NA | Performance similar to 50% zoom. See above. |
| 3) Describe the visual effect when the input video is changed abruptly; eg., vertical interval switch. (Delay, jerkiness, jaggedness, resolution, color, settling time.) | Blocking lasting less than 1/2 second. | Blocking lasting less than 1/2 second. | NA | Immediately. | NA | NA | Visual effect when input video is changed abruptly- Element in the image which differ from their levels in the old image will start to change in the first video frame and will reach within 5% of the correct level in about 4 frames (0.13 second). A final full resolution image will be normally achieved within 1 second of the input change, unless large areas of the new image are continuously changing. Due to the performance of the human eye, the reduced image resolution in the first second is not visually apparent. |

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE

| 3. BIT ERROR RATE PERFORMANCE | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-XI(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Condition 1. Data link error rate is 10 exp (-6). | | | | | | | |
| 1) Are the errors perceptible? Yes/No; | No. | No. | No. | No. | No. | No. | No. |
| 2) Describe the visual effect of the errors. (Blocks, lines, streaks, color changes, etc.) | | | | | No. | No. | |
| a) In the static part of the picture; | NA | NA | Operating the demand refresh and the picture is recovered. | NA | No. | No. | NA |
| b) In the motion part of the picture; | NA | NA | ditto. | NA | No. | No. | NA |
| 3) Does the receiver maintain complete synchronization? (Horizontal, vertical, color, audio); | Yes. | Yes. | Yes. | Yes. | Yes. | Yes. | Yes, all. |
| 4) Is scrambling/encryption affected in a system with this option? Yes/No; | No. | No. | Yes. | NA | No. | No. | No. |
| B. Condition 2. Data link error rate is 10 exp (-5). | | | | | | | |
| 1) Are the errors perceptible? Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | No. | Yes. |
| 2) Describe the visual effect of the errors. (Blocks, lines, streaks, color changes, etc.) | | | | | | | |
| a) In the static part of the picture; | Random blocks with transform basis vector patterns. | Random blocks with transform basis vector patterns. | Operating the demand refresh and the picture is recovered. | Part of line is color changing. | No. | No. | Very infrequent single element intensity or color errors, removed in a few seconds by normal systematic PCM updates. |
| b) In the motion part of the picture; | Same as static. | Same as static. | ditto. | Part of line is color changing. | No. | No. | Single element or limited horizontal lines, removed almost immediately due to further movement of the area. |
| 3) Does the receiver maintain complete synchronization? (Horizontal, vertical, color, audio); | Maybe. | Maybe. | Yes. | Yes. | Yes. | Yes. | Yes, all. |
| 4) Is scrambling/encryption affected in a system with this option? Yes/No; | No. | No. | Yes. | NA | No. | No. | No. |

(continued on next page)

TABLE 2.3-3: BIT ERROR RATE PERFORMANCE

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE (continued)

| 3. BIT ERROR RATE PERFORMANCE | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| C. Condition 3. Data link error rate is 10 exp (-4). | | | | | | | |
| 1) Are the errors perceptible? Yes/No; | Yes. | Yes. | Yes. | Yes. | No. | No. | Yes. |
| 2) Describe the visual effect of the errors. (Blocks, lines, streaks, color changes, etc.) | Same as 10 exp (-5). | Same as 10 exp (-5). | | | | | |
| a) In the static part of the picture; | | | Operating the demand refresh and the picture is recovered. | Part of line is color changing. | No. | No. | Single elements or limited horizontal line intensity or color errors, removed in a few seconds by normal systematic PCM updates |
| b) In the motion part of the picture; | | NA | ditto. | Part of line is color changing. | No. | No. | Single element or limited horizontal lines, removed almost immediately due to further movement of the area. |
| 3) Does the receiver maintain complete synchronisation? (Horizontal, vertical, color, audio); | No. | No. | Yes. | Yes. | Yes. | Yes. | Yes, all. |
| 4) Is scrambling/encryption affected in a system with this option? Yes/No; | No. | No. | Yes. | NA | No. | No. | No. |

(continued on next page)

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE (continued)

| 3. BIT ERROR RATE PERFORMANCE | COMPRESSION LABS,INC.(VTS 1.5E) | COMPRESSION LABS,INC.(REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-XI(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| B. Condition 4. Data link error rate is 10 exp (-3). | Same as 10 exp (-5). | Same as 10 exp (-5). | | | | | |
| 1) Are the errors perceptible? Yes/No; | | | Yes. | Yes. | Yes. | Yes. | Yes. |
| 2) Describe the visual effect of the errors. (Blocks, lines, streaks, color changes, etc.) | | | | | Streaks. | Streaks. | |
| a) In the static part of the picture; | | | Operating the demand refresh and the picture is recovered. | Streaks. | Streaks. | Streaks. | Frequent single element or limited horizontal line intensity or color errors. Normal PCM updates prevent total corruption of the image and will restore it in a few seconds when the error rate improves. |
| b) In the motion part of the picture; | | | ditto. | Streaks and stop of motion. | Streaks. | Streaks. | Single element or limited horizontal line errors, removed almost immediately due to further movement of the error. |
| 3) Does the receiver maintain complete synchronisation? (Horizontal,vertical, color, audio); | No. | No. | Yes. | Yes. Frozen picture for video synchronization lost. | Yes. | Yes. | Yes, all. |
| 4) Is scrambling/encryption affected in a system with this option? Yes/No; | | | Yes. | NA | No. | NA | No. |
| | | | | | | | Note: At all error rates, most errors are rejected or reduced in effect by the data decoding algorithm. |

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE

| 4. COMPRESSION TECHNIQUE | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(MCI) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Type of compression; | Differential transform coding (DXM) algorithm. | Differential transform coding (DXM) algorithm. | Inter-Intra frame combinational differential coding with multi-field subsampling and motion compensation. | H120 CCIR Recommendation. | Adaptive intra-inter frame predictive coding with motion compensation. | Motion compensation. | Conditional replenishment with movement detection. |
| B. Compression ratio achieved (compared to 8-bit PCM), Describe; | Basic pixel rate; 368x480x1.125x8x15=23,864,400b/s Compression ratio; 23.8M/1.5M=16:1. | Basic pixel rate; 368x480x1.125x8x15=23,864,400b/s Compression ratio; 23.8M/1.5M=16:1. | 1/40. | NA | 0.18-bit/sample. (1.544 mb/s). 0.06-bit/sample. (512 kb/s). | 0.18 bit/sample. (1.544 mb/s). | NA<br>Codec uses 22 1/2 out of 24 time slots for 1.54 mb/s video rate, direct video sampling at equal resolution (5 M samples/s luminance, 1 M sample/s each chrominance) requires 56 mb/s. |
| C. Compression technique description; | DIS Patent Compression Labs, Inc. | DIS Patent Compression Labs, Inc. | NA | H120 CCIR Recommendation. | Bit rate reduction is achieved using the motion compensated interframe coding combined with complex interframe coding. This is almost equal algorithm which is for Part 3 codec of CCITT Recommendation. | Bit rate reduction is achieved using the motion compensated interframe coding. | Sampling, movement detection, conditional replenishment with variable length DPCM coding as CCITT REC H120 Part A. Spatial filters use 5 video lines and the decoder takes data from both image fields to maximize static resolution. Temporal interpolators at encoder and decoder smooth frame rate conversion between input, transmission and output rates. |
| D. Summary of how compression is achieved; | | | | NA | | | |
| Reduced field/frame rate; | Yes. | Yes. | Yes. | | Yes. | Yes. | To allow frame rate conversion. |
| Reduced lines per displayed picture; | | | Yes. | | No. | No. | Yes, but not for data rate reduction. |
| Reduced pixels per display line; | Yes. | Yes. | Yes. | | Yes. | Yes. | |
| Reduced throughput precision; (Luminance and/or chroma) | Yes. | Yes. | | | No. | No. | |
| Reduced bandwidth; | | | | | No. | No. | |
| Other; | Differential transform DPCM. | Differential transform DPCM. | An adaptive control operates for field rates, lines/picture, and pixels/line. | | | | Conditional replenishment as per H120 Part 2A. |
| E. Future growth potential of this compression technique; | This technique has considerable potential below 512 kbps. | This technique has considerable potential below 512 kbps. | NA | NA | NA | NA | The compression techniques enable development in both higher and lower bit rates than those quoted. |
| F. Does codec compression technique comply with new CCITT H.120 Recommendation of 'Codecs for Videoconferencing Using *Primary Digital* Group Transmission'? | Yes, it is not the CEPT algorithm but falls into the 'others are not precluded' category. | Yes, it is not the CEPT algorithm but falls into the 'others are not precluded' category. | No. | Yes. | Yes. | No. | Complies fully with H120 Part 2A |
| G. Explain how codec complies with CCIR H.120 REC; | NA | NA | No. | NA | Part 3. | NA | Recommendation fully compliant-developed in conjunction with British Telecom. |
| H. Additional information on the compression technique. Reasons why the vendor's technique should be chosen as the standard for the Federal Government Telecommunication System | See attachment CLI-1. | See attachment CLI-1. | A configuration of the equipment is simple and the picture quality is maintained. | NA | NA | NA | See Addendum GEC #4. |

TABLE 2-3-4. COMPRESSION TECHNIQUE

PART 3. TECHNICAL SPECIFICATIONS: PERFORMANCE

| 5. AUDIO PERFORMANCE (Provide data for each channel) | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A. Bandwidth and frequency response; | 50 Hz to 5.5 KHz. | 50 Hz to 5.5 KHz. | 4 kHz or 7 kHz BW. | NA | 5 kHz. | 7 kHz. | 200 Hz. to 3.5 kHz. - 3 dB. |
| B. Harmonic distortion (state how distortion was measured); | - 44 dB distortion at 0 dBm and 400 Hz. | 0 dBm, 400 Hz, -44 dB distortion | NA | NA | NA | NA | N/A. |
| C. Total distortion (include harmonic distortion, cross-talk, noise, etc.); | - 44 dB. | - 44 dB. | NA | NA | Greater than 35 dB with 1 kHz at +0 dBm. | Greater than 35 dB with 1 kHz at +0 dBm. | N/A. |
| D. Audio / video delay; | 160 ms. (at 1.5 Mbps). | 160 ms. (at 1.5 Mbps). | +/- 10 ms. | NA | None. | None. | <30 ms difference. |
| Define measurement technique; | Calculated. | Calculated. | NA | NA | NA | NA | Independent video and audio delay measurement, confirmed by subjective observation. (all delays are digital and fixed) |
| E. Group delay; | NA | NA | NA | NA | NA | NA | N/A. |
| F. Insertion gain; | 0 +/- 0.5 dB. | 0 +/- 0.5 dB. | 0 dB +/- 0.5 dB. | NA | NA | NA | N/A. |
| G. Audio sampling rate; | 96 Kbps (CVSDM). (1.5 Mbps). | 96 Kbps (CVSDM). (1.5 Mbps). | 8 kHz (for 4 kHz) or 16 kHz (for 7 kHz). | NA | 16 kHz. | 16 kHz. | 8 K sample/sec. |
| H. Precision of encoding; | NA | NA | 8 bit or 13 bit. | NA | NA | NA | 8 bit A law codec. |
| I. Encoding technique; | CVSDM. | CVSDM. | PCM or sub-band ADPCM. | NA | ADPCM. | u-255 log law. | A law as per CCITT Rec G711. |
| J. Compression ratio compared to 8-bit PCM; | 1.5:1. | 1.5:1. | 1 or 1/3. | NA | 1/2. | 1:1 (pure PCM). | 1:1. |
| K. Audio bit rate; | 96 Kbps. | 96 Kbps. | 64 kb/s. | NA | 64 kb/s. | 128 kb/s. | 64 kb/s. |
| L. Performance at various bit error rates (describe degradation); | | | | NA | | | |
| BER=10 exp (-6); | No degradation. | No degradation. | NA | | Some click noise may rarely be perceived. | Some click noise may rarely be perceived. | Errors cause corruption of 1 sample. |
| BER=10 exp (-5); | No degradation. | No degradation. | NA | | Some click noise may be perceived. | Some click noise may be perceived. | No error propagation. |
| BER=10 exp (-4); | No degradation. | No degradation. | NA | | Some click noise may often be perceived. | Some click noise may often be perceived. | Audio output is muted if codec loses frame. |
| BER=10 exp (-3); | Some degradation. | Some degradation. | NA | | Muting function may activate. | Muting function may activate. | Alignment due to error rate worse than 10 exp (-3). |

TABLE 2.3-5: AUDIO PERFORMANCE

## 2.4 PART 4: PHYSICAL DESCRIPTION AND SPECIFICATIONS

This section provides information about the physical characteristics of the codecs; namely, mechanical, environmental, and physical interface. It is organized into four sections by function as shown below.

### 2.4.1 SECTION 1: MECHANICAL DIMENSIONS.

Specifies the size, weight, type of mount, and power requirements of the codecs.

### 2.4.2 SECTION 2: ENVIRONMENTAL DATA.

Defines temperature, humidity, and altitude ranges, and any environmental tests performed.

### 2.4.3 SECTION 3: EMI/EMC.

Defines EMI/EMC specifications, MIL standards, and FCC regulations which the codec meets.

### 2.4.4 SECTION 4: CONNECTORS.

Defines all video, audio, power, test, and ancillary signal interface connectors by number, type, location, voltage, and impedance.

PART 4. PHYSICAL DESCRIPTION AND SPECIFICATIONS

| 1. MECHANICAL DIMENSIONS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC II(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| | | | | | | | Cased : Rack mount |
| A) Size, Width; | 25 inches. | 19.25 inches. | 26 inches. | 19 inches. | 21 inches. | 22 inches. | 20.75 inches.:19 inch. |
| Height; | 51 inches. | 18 inches. | 67 inches. | 21 inches. | 45 inches. | 83 inches. | 23.75 inches.:13 rack units. |
| Depth; | 24 inches. | 22 inches. | 35 inches. | 16 inches. | 31 inches. | 24 inches. | 18 inches.:16.5 inches. High quality audio coder option is 19 inch 3 rack unit sub rack, other options fit 19 inch 4 rack unit sub rack. |
| B) Weight; | 330 lbs. | 109 lbs. | 400 lbs. | 30 kg. | 182 kg. | 280 kg. | 56 kgms. |
| C) Type of mount; | | | | | | | |
| Rack; | | Yes. | | Yes. | | | Yes. |
| Free standing; | Yes. | Yes. | Yes. | | Yes. | Yes. | Yes. |
| Other; | | | | | | | |
| Describe; | | | | | | | |
| D) Input power requirements; | | | | | | | |
| VAC; | 110. | 110. | 120. | 127 or 220 . | 115 +/-10% | 115 +/-10% | 115 or 240 |
| Amperes; | 20. | 8. | 10. | 50 and 60. | 15 (with option 3). | 13. | 2 |
| Watts; | | | 900,including optional function. | 200 | 1.76 kw (with options). | 1.5 kw. | 425 max. |
| Hertz; | 60. | 60. | 50/60. | | 50. | 50. | 50 or 60 for either voltage. |
| E) Additional information; | NA | NA | NA | NA | NA | NA | NA |

TABLE 2.4-1: MECHANICAL DIMENSIONS

PART 4. PHYSICAL DESCRIPTION AND SPECIFICATIONS (Continued)

| 2. ENVIRONMENTAL OPERATION | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(MC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A) Operating temperature range; | 50-75 degrees F. | 10 - 40 dergees C. | 0 to 40 degrees Centigrade. | 5 to 45 degrees Centigrade. | 41 to 104 degrees Fahrenheit. | 41 to 104 degrees Fahrenheit. | 0 to 40 degree C. |
| B) Operating relative humidity range; | 5-60 % non-condensing. | 15-95 % non-condensing. | 10 to 90 %. | 90 %. | Up to 80%. | Up to 80%. | 10 to 80 % non-condensing. |
| C) Storage temperature range; | 50-90 degrees F. | 0 - 70 degrees C. | -40 to 60 degrees Centigrade. | -10 to +70 degrees Centigrade. | -10 to approx. +50 degrees Centigrade. | -10 to approx. +50 degrees Centigrade. | 0 to 60 degrees C. |
| D) Storage relative humidity range; | NA | NA | 10 to 95 %. | 90%. | Up to 95 % (non-condensing). | Up to 95 % (non-condensing). | 10 to 80 % non-condensing. |
| E) Operating altitude range; | NA | NA | NA | NA | 0 - 12,000 feet. | 0 - 12,000 feet. | NA |
| F) Environmental tests performed | NA | NA | NA | NA | Yes. | Yes. | NA |
| G) Additional environmental information; | NA | NA | NA | NA | NA | NA | Recommended for use in formal office conditions. |

TABLE 2.4-2: ENVIRONMENTAL OPERATION

PART 4. PHYSICAL DESCRIPTION AND SPECIFICATIONS (Continued)

| 3) EMI/EMC | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A) Does equipment meet any EMI/EMC specification? Yes/No; Specify; | Yes.<br>NA | Yes.<br>NA | Yes.<br>FCC Part 15, Class A. | NA | NA<br>UL. | NA | Yes.<br>FCC rules part is subpart 5, Class A limits. |
| B) Has equipment been tested to any MIL standard? Yes/No; Specify; | No.<br>NA | No.<br>NA | No. | NA | No. | No. | No.<br>Tempest proofed version in development. |
| C) Does codec comply with FCC regulations on interference? | Yes, Part 15 Class A. | Yes, Part 15 Class A. | Yes. | NA | NA | NA | Yes, meets classA radiation and conductive emissions specs. |

TABLE 2.4-3: EMI / EMC

PART 4. PHYSICAL DESCRIPTION AND SPECIFICATIONS (Continued)

| 4. CONNECTORS | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-XV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| A) Provide a complete description of all external video and sync connectors by type, number, location, impedance, etc.; | 7 video inputs,<br>3 video outputs,<br>all 75 Ohm, BNC located on lower rear of system. | 8 video inputs,<br>3 video outputs,<br>all 75 Ohm, BNC located on center rear of system. | BNC, 2, 75 Ohms unbalanced. | NA | 5 BNC, 75 Ohms. | 3 BNC, 75 Ohms. | See pages 2.11 and 2.12 of manual. |
| B) Provide a complete description of all external audio connectors; | 2 audio connectors, 600 Ohm, XLR, location same as 04. | 2 audio connectors, 600 Ohm, XLR, location same as 04. | XLR, 2. | NA | XLR-3-14. | XLR-3-14. | See pages 2.11 and 2.12 of manual. |
| C) Provide a complete description of all external ancillary digital connectors; | 6 digital connectors,<br>DB25P and DB37P,<br>location same as 04. | 6 digital connectors,<br>DB25P and DB37P,<br>location same as 04. | NA | NA | DB-25-S for low speed data x1,<br>DC-37-P for high speed data X2. | DB-25-S. | See pages 2.11 and 2.12 of manual. RS-232C multiplexer module option uses standard 25 way D-type connectors for each channel. |
| D) Provide a complete description of all external power connectors; | One 110 volt, 30 amp twist lock and three A/C outlets-standard three prong. | One 110 volt, standard 3 pronged plug. | Cliping terminal. | NA | Receptacle No. 2315 (Hubbell). | Receptacle No. 2315 (Hubbell). | IEC standard mains input socket. |
| E) Provide a complete description of all external test and BITE connectors; | 3 RS-232C, DB5. | 3 RS-232C, DB5. | NA | NA | Socket DC-37-S. | Socket DC-37-S. | See pages 2.11 and 2.16 of manual for test system output signals. No test inputs required as tests are always operational. |
| F) Provide a complete description of all other external connectors including function type, location, impedance, bit rate/bandwidth, etc.; | T1-DB15P, 100 Ohm, 1.544 Mbps-512 Kbps,<br>RS-449, DB37P, 1.544 Mbps-512 Kbps.<br>Alrms - Cinch Jones 8 pin.<br>Location same as 04. | T1-DB15P, 100 Ohm, 1.544 Mbps-512 Kbps,<br>RS-449, DB37P, 3.136 Mbps - 384 Kbps.<br>Alarms - DB 15P.<br>Location same as 04. | Refer to Fujitsu Publication DE-12592. | NA | Socket DC-37-S for alarms. | NA | See pages 2.11 and 2.12 of manual for channeland clock control connectors. |

TABLE 2.4-4: CONNECTORS

## 2.5 PART 5: OTHER PRODUCT DATA

This section contains a variety of pertinent information about the codecs which does not fit logically into the previous categories. The data is divided into seven subsections to facilitate location of specific information as shown below.

2.5.1 SECTION 1: STATUS / ALARMS.
Description of codec status indicators and alarms, defining the function, location, and type.

2.5.2 SECTION 2: BITE.
Description of built-in test equipment by function, type, and degree of automation.

2.5.3 SECTION 3: FRONT PANEL / OPERATOR CONTROLS.
Describes all front panel / operator controls by function, location, and procedure.

2.5.4 SECTION 4: ENCRYPTION / SCRAMBLING.
Description of built-in or optional encryption / scrambling capability including algorithm, data stream composition, key method, etc.

2.5.5 SECTION 5: TV GRAPHICS.
Description of standard or optional TV graphics capability, signal format, effect on video transmission, etc.

2.5.6 SECTION 6: DOCUMENTATION.
Tabulation of documentation provided, or available, for the operation and maintenance of the codec.

2.5.7 SECTION 7: BROCHURES / TECHNICAL PAPERS
Tabulation of technical literature available regarding the equipment, its operation, and its application.

PART 5. OTHER PRODUCT DATA

| OTHER PRODUCT DATA | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| 1. Status / Alarms<br>Please provide a description of all status indicators and alarms defining function, location, type, etc.; | Alrms monitors power, air flow, temp., input video, channel error, audio overload, T1 rec. fail. door open, rec. frame,CPU. Status monitors encryption, bit rate, alarms, data ports, comm. ports, graphics tone oscillator, audio, input camera, room controller, console, remote diagnostics. | Alrms monitors power, air flow, temp., input video, channel error, audio overload, T1 rec. fail, rec. frame,CPU. Status monitors encryption, bit rate, alarms, data ports, comm. ports, graphics tone oscillator, audio, input camera, room controller, console, remote diagnostics. | Please refer to Fujitsu Publication BE-12592, 'Fujitsu Efficient Digital Image Transmission System'. | An alarm board is included in the codec (local and remote). | Alarm indications= Video, ALS, Remote,Coder, Sync,Key, Decoder, PS (NFB), Fan. | NA | Indicators on the front of PCB's show codec operating mode and in codec operation and in incoming data. Alarm status connectors on rear panel duplicates many indicators. See pages 2.16, 3.4, 5.5, 5.6, 5.11 to 5.14 of manual |
| 2. Bite<br>Please provide a description of any BITE provided with equipment defining the function, type, degree of automation, etc.; | ? | ? | NA | NA | NA | NA | Internally generated test data continuously checks correct operation of major video data paths. Microprocessor units continually EIE self test routines during normal operation. Data decoding system detect most fau;lts in the decoder and the remote encoder units. |
| 3. Front panel / operator controls<br>Please provide a description of all front panel / operator controls defining function being controlled, procedure, etc.; | Power, reset, video, and audio loop-backs. | Power and keypad which provide access to all operational and diagnostic controls. | Please refer to Fujitsu Publication BE-12592, 'Fujitsu Efficient Digital Image Transmission System'. | NA | Main Power On/Off,<br>Normal Mode Select,<br>Loop-back Selection,<br>Video Switch Control,<br>Bit Rate Selection,<br>Encryption Key Load,<br>VSP Control,<br>Function Key On/Off,<br>Ten Keys with combinations of above,<br>Alarm Test,<br>Character Displays,<br>Local Operation / Remote Control Operation Selection. | Main power on/off, control sw (local/remote/CPU off), loopback, test, sum test, etc. | Operational control is by TTL signals to rear panel D-type connectors. Internal switches allow configuration of codec modes to match external equipment. See pages 2.13 to 2.16 and 3.3 of the manual. |
| 4. Encryption / Scrambling<br>Please provide a description of encryption / scrambling circuits provided defining the algorithm, output data stream composition, method of changing key, and any other pertinent data; | AMD 9510 circuit- DES algorithm. The 56 bit, hex key is changed at the system console. Must be odd parity. Entry of key is not echoed back to the system console. | AMD 9510 circuit- DES algorithm. The 56 bit, hex key is changed at the system console. Must be odd parity. Entry of key is not echoed back to the system console. | Please refer to Fujitsu Publication BE-12592, 'Fujitsu Efficient Digital Image Transmission System'. | NA | Encryption= DES algorithm.<br>Scrambling= Sync, 8 steps (I exp 8 +I exp 6 +I exp 5 + I exp 4 +1). | Encryption= DES algorithm.<br>Scrambling= Sync, 8 steps (I exp 8 +I exp 6 +I exp 5 + I exp 4 +1). | Encryption option cards,encrypting audio, video and user data using encryption standard (DES) algorithm in output feed back mode. Encryption keys entered and changed at any time using local keyboards or calculated internally using secure public key algorithm for exchange of DES encryption keys. |

(continued on next page)

TABLE 2 5 1. OTHER PRODUCT DATA

PART 5. OTHER PRODUCT DATA (continued)

| OTHER PRODUCT DATA | COMPRESSION LABS, INC. (VTS 1.5E) | COMPRESSION LABS, INC. (REMBRANDT) | FUJITSU AMERICA, INC. | CIT ALCATEL | NEC (NETEC-IV) | NEC (NETEC-II(NC)) | GEC VIDEO SYSTEMS |
|---|---|---|---|---|---|---|---|
| 5. TV Graphics input / output<br>Please provide complete description of input / output video signal if codec has provision for processing and transmitting a separate TV graphics signal. Include sampling rate, encoding algorithm, precision of encoding, color or monochrome, horizontal and vertical resolution and method for specification, transmission time, effect on motion codec signal. Also specify if there is a separate TV graphics input / output signal connector and what TV standard does the graphics signal comply with (ie, NTSC, R,G,B, RS-170, etc.) | Sample rate: same as full motion.<br>Encoding algorithm; Same as full motion with zero error coding.<br>Precision of encoding; Same as full motion with zero error coding.<br>Color or Monochrome; Both.<br>Horizontal Resolution;368 Pixels (active area).<br>Vertical Resolution;480 Pixels.<br>Transmission time;1/2 to 3/4sec.<br>Effect; Motion image frozen during transmission.<br>Separate connector; Yes.<br>Complies with; NTSC, RGB, PAL, RS-170. | Sample rate; 2 x full motion, 14.3 Mbps.<br>Encoding algorithm; Same as full motion with zero error coding.<br>Precision of encoding; Same as full motion with zero error coding.<br>Color or Monochrome; Both.<br>Horizontal Resolution;736 Pixels (active area).<br>Vertical Resolution;480 Pixels.<br>Transmission time; 1 to 2 sec.<br>Effect; Motion image frozen during transmission.<br>Separate connector; Yes.<br>Complies with; NTSC, RGB, PAL, RS-170. | NA | NA | For graphics transmission<br>Sampling Rate-14 kHz(4xfsc)<br>Color Resolution<br>Mode 1- 480 x 384 lines<br>Mode 2- 480 x 768 lines<br>Effect on motion signal - freeze the motion picture<br>Transmission time<br>Mode 1- 0.5 to 1.5 sec.<br>Mode 2- 1.0 to 3.0 sec.<br>Graphics input/output- NTSC. | For graphics transmission<br>Sampling Rate-14 kHz(4xfsc)<br>Color Resolution<br>Mode 1- 480 x 384 lines<br>Mode 2- 480 x 768 lines<br>Effect on motion signal - freeze the motion picture<br>Transmission time<br>Mode 1- 0.5 to 1.5 sec.<br>Mode 2- 1.0 to 3.0 sec.<br>Graphics input/output- NTSC. | See Addendum GEC #5. |
| 6. Documentation<br>Please list and describe all manuals and documents provided with the equipment for operation maintenance, and repair. Please include document date, title, and revision number; | Training manual-8401143-B,3/84.<br>Operation and Maintenance Manual-8401138, 3/84. | Operation and Maintenance Manual. | Please refer to Fujitsu Publication DE-12592, 'Fujitsu Efficinet Digital Image Transmission System'. | NA | Instruction manual for NETEC-IV TV CODEC; BOI-E[illegible] TBD. | Instruction manual for NETEC-II(NC) TV CODEC;<br>BOI-E04328 Issue 1 January 1984. | 525 line (1.5/0.77 mb/s) video teleconference codec studio version maintenance manual (Volume 1) DOC. No. TP H/846-1 Issue 1 Aug 84.(Operating, installation and maintenance instructions). |
| 7. Brochures / Technical Notes<br>Please provide copies of all brochures and technical notes or other material concerning this equipment, its operation, and its application. | Notes enclosed. | Notes enclosed. | Please refer to Fujitsu Publication DE-12592, 'Fujitsu Efficinet Digital Image Transmission System'. | NA | See Addendum NEC-1. | See Addendum NEC-1. | Notes enclosed. |

2.6 ADDENDA.

Several of the vendors supplemented the response to certain of the questions with comparatively lengthy statements which could not be included in the tabulation due to format restrictions. The responses to these questions are included in this section, each on a separate page. The question to which the response correlates is included on that page as is a reference to the location of the question in the preceding tabulations.

The question / response tabulations clearly indicate where an elaboration on the response is to be found in the addenda.

2.6.1 ADDENDUM CLI #1

COMPRESSION LABS, INC.

RESPONSE TO PART 3, SECTION 4, QUESTION H.

QUESTION H.
Additional information on the compression technique. Reasons why the vendor's technique should be chosen as the standard for the Federal government Telecommunication System.

RESPONSE.

1) This same machine is switchable to operate at lower bit rates thus allowing less expensive transmission.

2) Superior picture quality over speed range of interest.

3) CLI ability and commitment to improve product further.

4) Flexibility of algorithm to be optimized at higher and lower bandwidths to achieve desired picture quality at bandwidths available.

5) Functionality of codec outside area of picture quality per se.

6) Large existing base in organizations with which the Federal Government will want to teleconference.

7) U.S. based engineering which allows good communication with customer on technical issues and special modifications needed to address special requirements. Also secret and top secret clearances of technical and marketing people needed for sensitive system implementations.

8) Willingness of manufacturer to be responsive to growing application requirements within both government and defense segments.

2.6.2 ADDENDUM GEC #1

GEC VIDEO SYSTEMS

RESPONSE TO PART 2, SECTION 5, QUESTION N.

QUESTION N; Other transmission rates standard for this codec.

RESPONSE.

Codec Transmission Channel Formats

The codec operates on channel clock rates of 1.544 Mbit/s and 772 Kbit/s, selectable as required. While operating at the 1.544 Mbit/s channel clock rate, the codec fully implements CCITT recommendations H120 Part 2A and H130 Part 2. It can communicate directly with a 625 line 50 Hz 2.048 Mbit/s codec without external standards conversion, just using an external remultiplexer to convert between the 1.544 Mbit/s and the 2.048 Mbit/s frame structures.

The codec will also if required vacate 12 timeslots in each frame to give a total of 12 time slots containing signalling, audio, user and video data. This mode is enterred automatically if required using currently spare bits 3.1.7 and 4.15 in the H130 framing structure to controll the data rate being used. Hence the codec can operate in a mode allowing external equipment to multiplex two codec channels into a single 1.544 Mbit/s channel, or to remultiplex the codec into a 772 Kbit/s clock rate channel to allow lower transmission costs over satellite links.

The codec can also be set to operate with a channel clock rate of 772 Kbit/s. The codec then operates with a frame structure containing frames of 12 timeslots plus 1 alignment bit every two frames, giving blocks of 193 bits including 1 alignment bit in each block. The frames are constructed in a similar way to H130, with time slot 1 audio data, timeslot 2 in odd frames signalling data, timeslot 2 in even frames and two other timeslots selectable for user data ports and the remaining 8 to 10.5 timeslots used for video data. This framing structure can be easily converted by an external remultiplexer to the structure described above for the codec using a 1.544 Mbit/s clock rate with 12 vacated timeslots.

2.6.3 ADDENDUM GEC #2

GEC VIDEO SYSTEMS

RESPONSE TO PART 3, SECTION 1, QUESTION D.

QUESTION D; Do any of the above change with motion pictures? Describe in detail.

RESPONSE.

Note:- To allow communication with a 625 line 50Hz codec using 2.048 Mbit/s channel, without external standards conversion, the normal transmission field rate is reduced to 50 fields/s, using temporal interpolation of input and output video to smooth the field rate conversion. This process is selected automatically when required.

2.6.4 ADDENDUM GEC #3

GEC VIDEO SYSTEMS

RESPONSE TO PART 3, SECTION 2, QUESTION Y,d,7.

QUESTION Y; MOTION PERFORMANCE EVALUATION.
PART d; Condition 4. Up to 100% of the pixels change between frames;
SUBPART 7; Describe any other effects resulting from changes in picture content.

RESPONSE.

Note:- In all cases, subsampling is only used on motion areas and the resolution of static areas is left unchanged. The adaptive element subsampling prevents subsampling of vertical edges, to reduce considerably the subjective effect of the resolution loss. The movement perception of the human eye means that the loss of the motion area resolution is not normally perceptible.

2.6.5 ADDENDUM NEC #1

NEC AMERICA INC.

RESPONSE TO PART 5, QUESTION 7.

QUESTION 7.
Brochures/Technical Notes
Please provide copies of all brochures and technical notes or other material concerning this equipment, its operation, and its application.

RESPONSE.

BROCHURES

The Brochures/Technical Notes we prepare for the customer are listed below:

| TITLE | NUMBER | DATE | ISSUE |
|---|---|---|---|
| 1. NETEC-XI(MC) TV CODEC | E34128 | March 1984 | Issue 1 |
| 2. Technical Description of NETEC-XI(MC) TV CODEC | DEX-5547 | March 1983 | Issue 1 |
| 3. NETEC-XV TV CODEC | DPR-141E | May 1984 | Issue 1 |

COMPRESSION TECHNOLOGY REFERENCES

| TITLE | CONFERENCE | DATE |
|---|---|---|
| 1. Motion Compensated Interframe Coding for Video Conferencing | National Telecommu- | Nov. 1981 |
| 2. NETEC-6/3 Video Transmission Equipment for Teleconference | INTELCOM | Feb. 1979 |
| 3. Digital Television Transmission using bandwidth compression techniques | IEFE Communications Magazine | June 1980 |

## 3.0 TECHNICAL COMPARISON OF MOTION CODECS (1.5 Mb/s)

### 3.1 APPROACH

The previous section tabulated the data received from the various vendors using the exact wording of the responses. The tabularization is an aid in comparison of the responses on a question by question basis. The following sections will provide a discussion of the implications of the various questions and a summarized comparison of the responses on a functional basis rather than on a question by question basis.

The data used in these comparisons has been drawn from the responses to the questionnaire as provided by the vendors. None of the data has been verified by an independent source nor was the data in the questionnaire compared to that in the data sheets. However a proof copy of the final typed version of each vendor's response was sent to the vendor for concurrence as to accuracy and validity.

### 3.2 KEY SPECIFICATIONS AND PERFORMANCE PARAMETERS

The questionnaire submitted to the codec vendors requested extensive information about the codecs. Some of these specification and performance criteria are considered more important to overall codec performance than others. These specifications will therefore be discussed and compared in more detail in this section of the report. Generalized comments regarding some of these parameters are offered to define clearly the purpose of the questions as stated in the questionnaire which may otherwise not be obvious. These comments are presented on a purely technically clarifying basis and have no intended relationship to vendors or equipments.

### 3.3 INPUT AND OUTPUT VIDEO SIGNAL FORMATS

The input and output video signal formats determine the input and output devices with which the codec can interface. The transmission format is of great importance in understanding the system performance capability.

The accepted television format in the United States and in some of the rest of the world is defined as follows;

| | |
|---|---|
| Field rate: | 60 fields per second |
| Frame rate: | 30 frames per second |
| Interlace: | 2:1 |
| Lines / field: | 525/2 |
| Lines / frame: | 525 |

The line, field, and frame rate should be considered under three categories each of which affect the output presentation differently.

Input line, field, and frame rate.
Transmitted line,`field, and frame rate.
Output line, field, and frame rate.

The input line, field, and frame rate determine the sources of video signal with which the transmitter portion of the video codec can interface. All of the codecs within the scope of this report can interface with television signals of one or more standards. Therefore the source of video signals for these codecs can be a standard television camera providing NTSC television signals. Options are available in most codecs to accomodate PAL and RGB television signals. The source can also be a VTR for those codecs with a built-in time base corrector, or a VTR video signal which has the required time base stability. The input video format determines the upper limit of system image quality in terms of resolution, gray scale, color, and motion representation. The codecs communicate this video signal between terminals and display it in a manner which attempts to duplicate the original signal as closely as possible given the restrictions of a 1.544 Mb/s channel.

With regard to achieving this goal, an important consideration is the effect of the transmission channel on the transmitted field and frame rate. Because of the 1.544 Mb/s channel data rate restriction, only about 25,730 bits are available for transmission during each field interval. Real time transmission is, of course, impossible due to the unachievably high compression ratio required. In order to use the 1.544Mb/s channels, codec designers have developed ingenious techniques of transmitting even less data than required for a normally compressed picture. The data transmitted during a field interval is less than the amount of data required to define a field. However, using these techniques, a complete picture is reconstructed at the receive terminal. An orderly predetermined pattern of pixels, blocks, lines, etc., is normally transmitted. When the picture is not static, emphasis shifts more heavily to conveying the motion or change information. The channel capacity can provide data at a rate adequate to support only some reduced degree of motion or change portrayal. Usually the time correlation between input line, field, and frame rate and the transmitted data is lost. The receiver reconstructs the picture and correlates it with the local sync providing a conventionally refreshed video output signal. It is essential to understand that while the input and output signals may be in conventional formats, the intervening processing (in addition to compression) is the major factor affecting the system temporal performance capability and should be evaluated for each specific application.

The output line, field, and frame rate are a function of the design of the receiver portion of the codec. The reduction in the amount of transmitted data, as described above, must be restored at least to the extent that a standard video display format can be used. Information may have been to some extent discarded in the reduction process. Interpolated, repeated, or previously stored information may be used to fill in the restored video display format thereby minimizing motion degradation and quality deterioration. This is essential because the combination of the output line, field, and frame rate determine the type of display with which the codec can interface. All of the codecs discussed in this report can provide an output video signal which is compatible with readily available television display devices of the NTSC type. PAL or RGB type can be accomodated in some codecs depending on the options excersized.

## 3.4 RESOLUTION DATA COMPARISON

The concept of resolution in television systems using motion codecs of the type being discussed is somewhat complex.

First, the overall data rate is fixed at some value (1.544 Mb/s for the codecs under discussion). When the picture being transmitted contains very little or no motion, the overall sampling pattern, together with the effects of the image compression technique, set the major determinant to the amount of resolution which the output display can present. As the proportion of the picture containing motion increases, more of the data stream is devoted to conveying the motion effects and, unless the static areas are stored at the receiver, less is available for the transmission of static area resolution. Each codec uses a somewhat different technique.

Second, it is difficult to define resolution in the moving parts of the picture. If the picture is TV camera generated using, for example a vidicon, the moving areas inherently contain some amount of image `smear' due to the retentivity of the camera tube. Further `smearing' effects result from the fact that the image has moved across some area of the photo-sensitive surface during the 1/60 or 1/30 second integration period. The average viewer has learned to accept this degradation to the extent to which it occurs in home TV. However in teleconferencing applications, valid data may exist in these areas and the viewer's ability to ascertain its meaning may be important. A corollary to this concept is pictures in which alpha-numeric data is updated. This can be data generated directly by a computer or `flip chart' type data. In this case, there is an interplay between resolution and motion capability in defining how quickly the changed data can be recognized. Defining resolution in motion or change areas of the picture is, at best, difficult. Therefore, three aspects of resolution should be considered.

First, the resolution in a static image.
Second, the resolution in the static portion of a picture containing some degree of change.
Third, resolution within the area of the picture containing motion.

The latter may not be of as much importance as the `settling time'; that is, how quickly the data in the area containing change can be ascertained by the viewer.

The resolution in static images is determined by the system sampling format, the transmission format, and the display format. (These factors affect many other performance parameters in addition to resolution.) The following is an overview of the concepts involved.

The codecs all sample the same type of input video signal which has 262.5 lines per field (60 fields per second) and 525 lines per frame (30 frames per second) interlaced 2:1. Thus each equipment starts with the same potential quality. Each of the codecs has a different sampling and transmission format and a different reconstruction technique to produce the display format.

The number of luminance samples per line fall into two basic categories.

a) Nominally 375 luminance samples per active line interval. This category actually includes 368 and 384 samples per active line interval (a spread of 4%).
b) Nominally 256 luminance samples per active line interval.

One vendor lists 910 and 455 samples per active line while the given sampling rate of 7.16 M samples per second would indicate 368 samples per active line interval. It is included in category `a'.

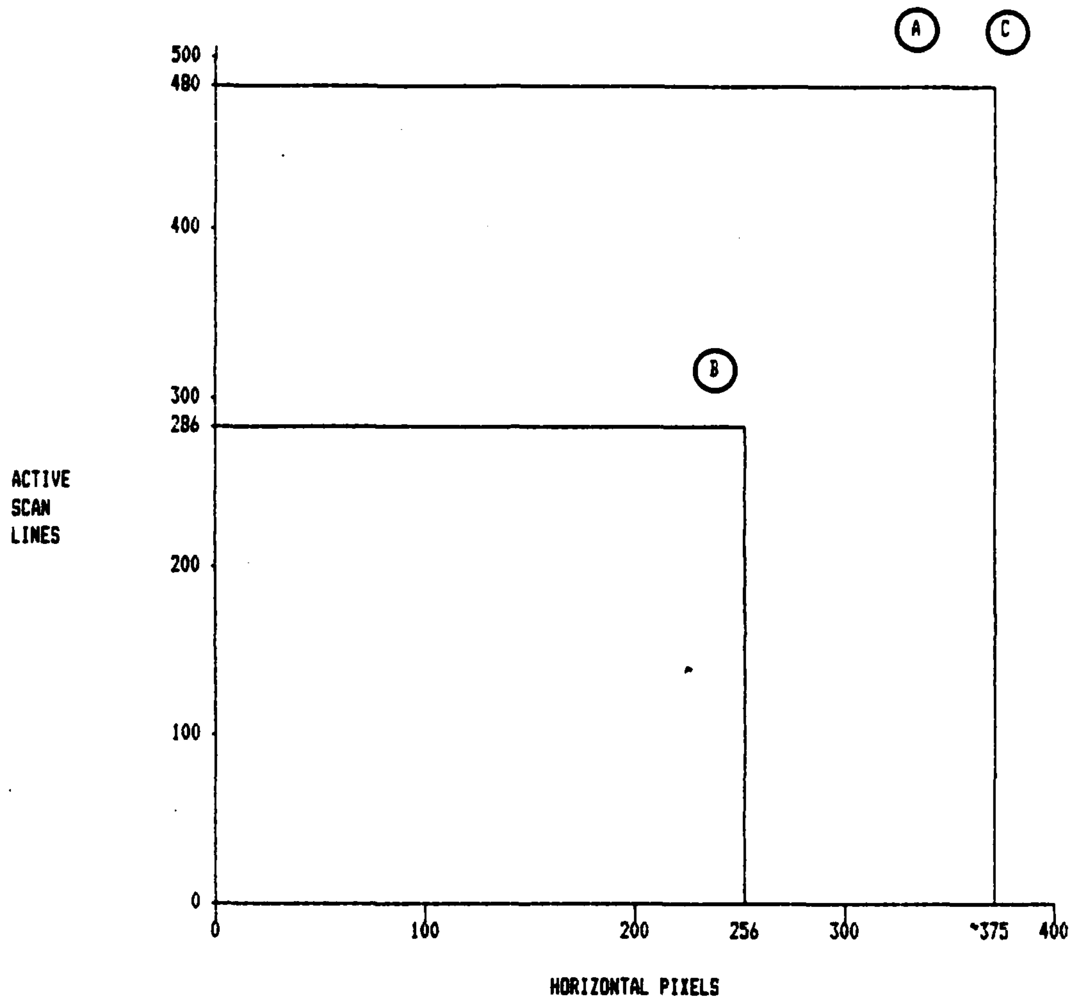
The data provided in response to questions about the transmission format is considerably different from that in response to the sampling format. Transmission format is defined as the equivalent amount of data transmitted in terms of lines, fields, and frames. The responses can be divided into three categories. Note that this data may apply only to a static picture.

| | Fields/Frames per Second | Lines per Field/Frame |
|---|---|---|
| a) | 60/30 | 256-262/512-525 |
| b) | 60/30 | 143/286 |
| c) | 30/15 | 240/480 |

Finally, responses indicate that the output video is always reconstructed so that 60 fields with 262.5 lines each, and 30 frames with 525 lines each interlaced 2:1 are presented per second. It is not clear whether repeat field/frame or interpolation is used to reconstruct the missing data. The effect of repeat field / frame or interpolation on the overall resolution is not clear.

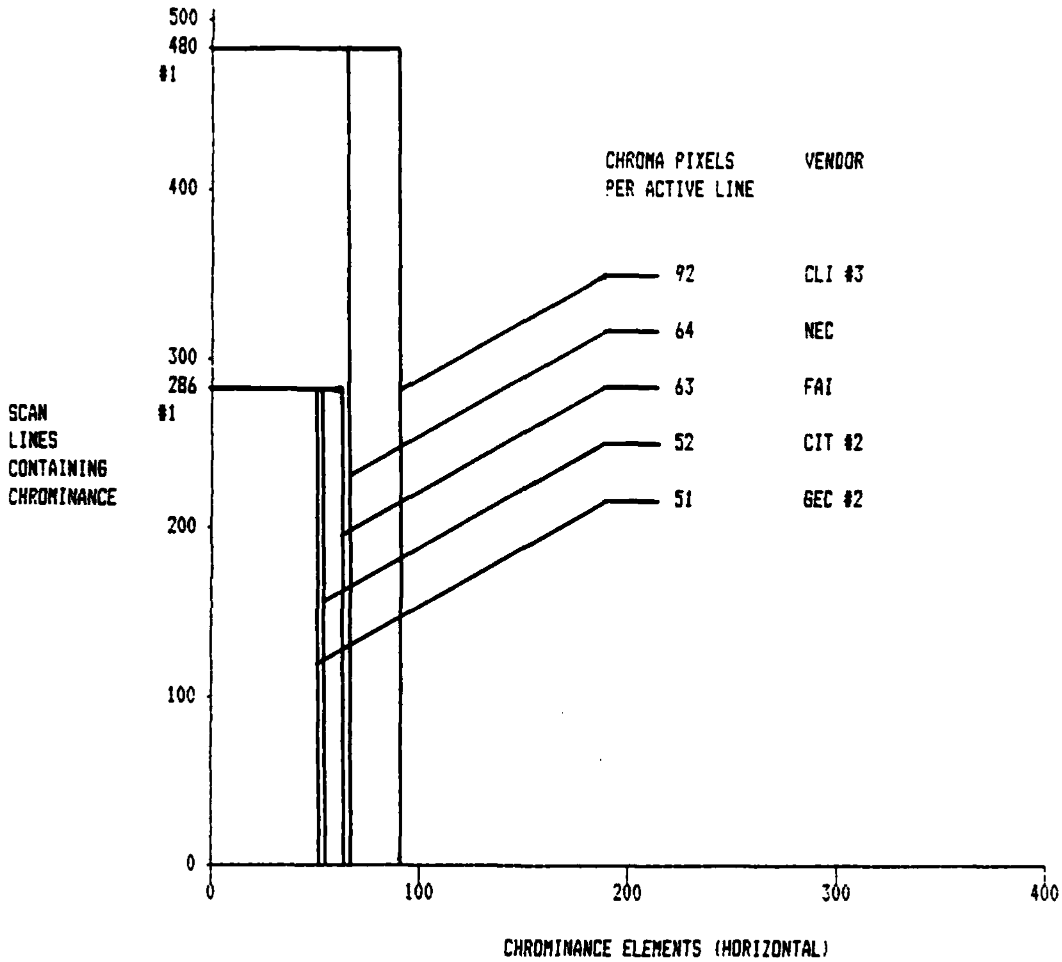
Figure 3.4-1 graphically summarizes the overall luminance resolution for the three categories defined above. This presentation takes into account the sampling rate, transmission format, and the display format.

Figure 3.4-2 graphically shows the overall chrominance resolution for the various codecs.




| CATEGORY | DESCRIPTION |
|---|---|
| A | FAI AND NEC. |
| B | CIT AND GEC. |
| C | CLI. |

FIGURE 3.4-1; LUMINANCE TRANSMISSION COMPARISON




#1 - Nominal.
#2 - 286 lines are transmitted per frame although a full raster is displayed.
#3 - 15 frames are transmitted per second.

FIGURE 3.4-2; CHROMINANCE RESOLUTION COMPARISON

## 3.5 ANALOG TV PERFORMANCE COMPARISON.

The judgement of video transmission system performance is generally made on a basis of the output displayed picture quality based on a known or assumed quality of the input picture. Conversely, if the input video signal can be assumed to be of suitable quality, all of the degradation seen in the output picture or measured in the output video signal is caused by the various electrical characteristics of the transmission channel. After many years of experimentation and experience, a set of standards have been developed and accepted for these characteristics of a standard video transmission channel which will assure a satisfactory output picture for a suitable input video signal. These characteristics are defined in terms of impairments measured on the output video signal. One set of these parameters is specified in Electronic Industries Association publication "Electrical Performance Standards for Television Relay Facilities, RS-250-B".

A video codec pair with the interconnecting digital circuit constitute a video transmission system. As such the same feature applies; namely, that, given a high quality input video signal, any degradation observed in the ouput picture quality is due to the characteristics of the transmission channel (codec and digital circuit). The digital circuit operating at a very low error rate will not contribute to picture degradation. In this case the codec pair alone determine the received picture quality. A set of transmission channel electrical characteristics could be developed to predict the quality of the output video picture. However, just as in the case of the standard video channel, this requires substantial experimentation and experience to determine how and to what degree the picture quality is affected by changes in the channel transmission characteristics. The art of digital video transmission and in particular digital video transmission at 1.544 Mb/s has not yet reached this state particularly in view of the variety of techniques used to achieve compression and motion transmission.

In Part 3 Section 1 Question U and V, the vendors were asked to measure various major signal parameters of a video signal transmitted through the codec. These parameters are susceptible to problems in conventional analog transmission systems, and as a result will cause specific output picture degradations. The following tabulation is a synopsis of the responses to these questions for comparison with the accepted EIA standards tabulated later.

TABLE 3.5-1; SYNOPSIS OF ANALOG PERFORMANCE RESPONSES

| SELECTED CHARACTERISTICS | RANGE OF RESPONSES | |
|---|---|---|
| | LOW | HIGH |
| Luminance-Chrominance Gain Inequality; | 0 dB. | 14 IRE |
| Luminance-Chrominance Delay Inequality; | +/- 54 ns | 100 ns |
| Signal to Noise Ratio | >50 dB. | >45 dB. |
| Differential Gain; | 6% | 8% |
| Differential Phase; | <4 Deg. | 6 Deg. |
| Field Time Waveform Distortion; | 3 IRE | 3% |
| Line Time Distortion; | 2 IRE | 3% |
| Frequency Response; | 2.7 MHz. | |

TABLE 3.5-2; EIA RS-232-B PERFORMANCE STANDARD

| SELECTED CHARACTERISTICS | TYPE OF TRANSMISSION CIRCUIT | | | | |
|---|---|---|---|---|---|
| | SHORT | MED. | LONG | END-END | SAT |
| Luminance-Chrominance Gain Ineq.(IRE); | +/-1 | +/-4 | +/-7 | +/-7 | +/-4 |
| Luminance-Chrominance Delay Ineq.(ns); | +/-20 | +/-33 | +/-54 | +/-60 | +/-26 |
| Signal to Noise Ratio | | | | | |
| 10KHz - 5.0 MHz.(dB); | 67 | 60 | 54 | 54 | 56 |
| 0 - 10 KHz.(dB); | 53 | 48 | 44 | 43 | 50 |
| Differential Gain (%); | 2 | 5 | 8 | 10 | 4 |
| Differential Phase(Degrees); | 0.5 | 1.3 | 2.5 | 3.0 | 1.5 |
| Field Time Waveform Distortion(IRE); | +/-3 | +/-3 | +/-3 | +/-3 | +/-3 |
| Line Time Distortion(IRE); | 0.5 | 1.0 | 1.5 | 2.0 | 1.0 |
| Frequency Response | See Figure 3.5-1 | | | | |

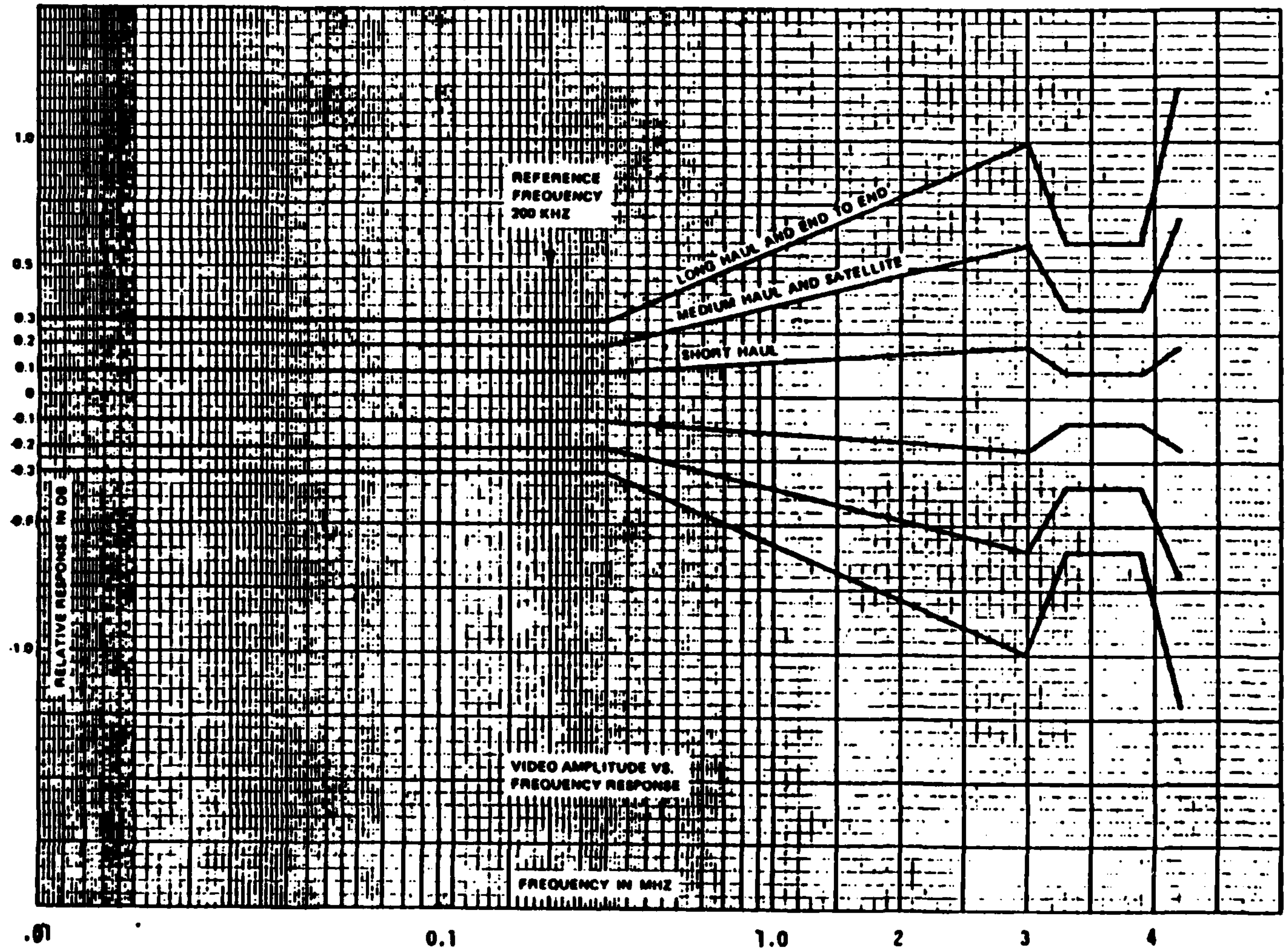



FIGURE 3.5-1; VIDEO AMPLITUDE-FREQUENCY RESPONSE

## 3.6 COMPRESSION TECHNIQUE COMPARISON

The compression algorithms used by the various vendors are all very sophisticated. The vendors are to be commended for reducing to a practical implementation these very complex concepts in the very short time since their inception.

The data provided by the vendors regarding their compression algorithm is understandably brief. They are in a very competitive market and the details of the compression algorithm and, perhaps even more so, the method of implementation of the algorithm are proprietary. The vendors have, however, responded with brief but meaningful information. It is difficult to comment on performance of the various algorithms, one with another based on this limited information.

The reader is referred to a series of three companion studies, performed by Delta Information Systems for the National Communications System in August, 1985 under Modification P00004 of Contract Number DCA100-83-C-0047.

- "The Development of a Video Tape to Test Teleconferencing Codecs",
- "The Development of a Methodology to Test Video Codecs Used in Teleconferencing",
- "The Test and Evaluation of Teleconferencing Video Codecs Transmitting at 1.5 Mbps

The input to the codecs was a high quality video tape recording of a carefully controlled set of scenes developed specifically for the purpose of evaluating the motion performance of the codecs. The motion performance of the codec is very dependent on the compression algorithm and as a result the output tape is an excellent indicator of the performance of the compression algorithm.

The following is a tabulation of the generic compression methods employed by the various vendors.

Differential transform coding.
Inter-intra frame combinational coding with multi-field subsampling and motion compensation.
H120 CCIR Recommendation.
Adaptive intra-inter frame predictive coding with motion compensation.
Motion compensation.
Conditional replenishment with movement detection.

This is an impressive list of compression techniques. The specific algorithms are undefined and therefore cannot be commented upon. It is apparent that most of them utilize motion detection and/or compensation as a major portion of the algorithm indicating the emphasis placed on the accurate reproduction of the transmitted scenes with motion.

Again, the reader is referred to the DCA initiated study series on the ability to transmit motion video by the available codecs.

### 3.7 DIGITAL INTERFACE COMPARISON

The 1.544 Mb/s digital motion codecs usually interface with a DS-1 transmission circuit which has highly defined interface and transmission characteristics. The codec output data stream characteristics and the receive signal requirements for the codecs as determined from the responses to the questionnaire are tabulated below and compared to the interface specification for a DS-1 circuit. The entries are not made for each codec but for the range of each parameter as found in the responses.

The digital interface formats used for the ancillary digital ports in the various codecs are also discussed below.

#### 3.7.1 DIGITAL VIDEO TRANSMISSION INTERFACE.

The digital video interface characteristics are compared with the characteristics specified in the ATT Compatibility Bulletin No. 119 and various ATT multiplex compatibility specifications in the tabulation shown in Table 3.7-1. The range of vendor responses is tabulated next to the ATT specification to facilitate comparison. The reader can refer to Part 2, Section 5 of the responses to determine the interface characteristics used by any one of the vendors in their codecs.

The comparison shown in Table 3.7-1 will permit the reader to determine the overall degree of compatibility of the codecs with the ATT DS-1 interface requirements. A similar analysis can be performed if other interface standards are required.

TABLE 3.7-1; COMPARISON OF ATT DS-1 SPECIFICATION AND CODEC INTERFACE RESPONSES

| PARAMETER | ATT SPECIFICATION | RANGE OF VENDOR RESPONSES |
|---|---|---|
| Precise data rate; | 1.544 Mb/s. | 1.544 Mb/s. |
| Tx data rate accuracy; | +/- 130 ppm,<br>CCITT= +/- 50 ppm. | +/- 30 ppm, +/- 50 ppm,<br>10 exp(-5). |
| Req'd rcv data accuracy; | +/- 50 ppm. | +/- 50 ppm, +/- 150 ppm,<br>+/- 5%. |
| Transmit signal level; | 2.4 to 3.6 V peak,<br>CCITT= 3+/-0.7 V peak. | 1 V, 3 Vp-p, others cite<br>CCITT Rec. G.703. |
| Impedance; | 100 Ohms. | 100, 110, 120 Ohms. |
| Signal format; | Bipolar. | Bipolar, Bipolar/NRZ. |
| Encoding; | AMI. | AMI, B8ZS, HDB3. |
| Max. no. like symbols; | 0's = 15, >12.% ave.<br>1's density. | 1's=7, 15,and unlimited.<br>0's = 15. |

3.7.2 ANCILLARY DIGITAL SIGNALS.

All of the vendors provide ancillary digital data channel inputs in their codecs for the transmission of data associated with teleconferencing. The range of the responses is tabulated below.

TABLE 3.7-2: COMPARISON OF ANCILLARY DIGITAL CHANNEL RESPONSES

| Parameter | Range of Responses |
| --- | --- |
| Number of ports; | Two vendors provide 1 port, the rest provide three ports. |
| Signal format; | Three provide RS-232C ports, three provide RS-449 ports, and four provide RS-422 ports. |
| Signal type; | Two vendors provide asynchronous ports and all provide synchronous ports. |
| Data rates; | The codecs provide the following combinations<br>a) 1200 baud, 9.6Kb/s to 448 Kb/s.<br>b) 1200 , 2400, or 4800 baud.<br>c) 32 Kb/s and 64 Kb/s.<br>d) 2400, 4800 B/s, 56, 112, 224 Kb/s.<br>e) 50 to 19200 B/s, 32 and 64 Kb/s. |
| Is an output clock avail; | Four vendors provide an external clock, one does not. |
| Bit/clock rate stability; | 10 exp(-5), +/- 30 ppm, +/-50 ppm. |
| Are bits for ancillary digital channels taken from picture transmission; | Three vendors responded `yes',<br>one provided no answer,<br>one responded `yes (RS-449)'. |

### 3.8 BIT ERROR RATE PERFORMANCE

In the questionnaire, the vendors were requested to supply performance data for the codec operating in a channel with specific bit error rates. The reader can analyze the data presented in view of the bit error rate statistics of the communication circuits available to him. The commercial carriers in the United States generally provide a very high quality of service so that in only rare instances will the performance drop below 10 exp(-6). When the error rate does increase, particularly in terrestrial circuits, it is often due to a short temporary outage. The following is a synopsis of the data provided.

#### 3.8.1 PERFORMANCE AT BER = 10 EXP(-6).

At 1.544 Mb/s only 1.5 errors will occur per second. The vendors unanimously indicate that the effect of this error rate on the output picture is not perceptible. 1.5 errors per second implies one error every 40 fields. The effect of the error could occur in the luminance, chrominance, synchronization, audio, or ancillary part of the transmitted information. In general, the video transmission requires the largest portion of the data bits and therefore the probability is that the error would most likely manifest itself in the output picture. The implication is that the signal processing used within the codec minimizes the effect of the error so that it is not noticeable.

#### 3.8.2 PERFORMANCE AT BER = 10 EXP(-5).

At 1.544 Mb/s, 15 errors will occur per second. The equivalent of every fourth field will contain an error. All but one vendor indicate that some effect of the bit errors will be perceptible in the output picture. The effect of the data error on the output picture is determined by the compression technique employed in that codec. Three types of effects were described by three different vendors as being observable at this error rate.

a) Random blocks with transform basis vectors.
b) Part of a line changes color.
c) Single element intensity or color error.

All vendors indicate that their system would maintain synchronization at this error rate except for one who qualifies this function as "maybe". Scrambling / encryption, if supplied, also appears not to be affected except for one vendor.

### 3.8.3 PERFORMANCE AT BER = EXP(-4)

The number of errors at this rate is about 150 errors per second or the equivalent of about 2.5 per field. Again, all but one vendor indicate that the errors will be visible in the output picture. The effects of the errors are the same as those described above. It is assumed that the frequency of occurrence of the artifacts in the picture will increase by the same factor as the increase in the error rate if the error distribution is totally random because the error rate is still comparatively low on a statistical basis.

All vendors except for one indicate that their system will maintain synchronization at this error rate. This vendor, who responded "maybe" at 10 exp(-5) BER, indicates that the codec will not maintain synchronization at 10 exp(-4) BER. Only one vendor responded that the scrambling / encryption will not be affected.

### 3.8.4 PERFORMANCE AT BER = 10 EXP(-3).

At this error rate about 1500 errors will occur per second or the equivalent of about 25 per field. All codecs now show effects of the errors. An additional category of error effect is indicated as "streaks". In addition one of the vendors indicates that the effect lower error rates had in his codec has changed from "changing color in part of a line" to "streaks" and "stopping of motion".

Synchronization appears to be maintained in all but one codec although a second codec vendor adds "frozen picture for video synchronization is lost". Only one vendor responds that scrambling / encryption is not affected.

### 3.9 MOTION PERFORMANCE COMPARISON

The motion performance of a codec, or any other display system for that matter, is a very difficult parameter to rate quantitatively. First of all, motion must be defined. In a scene such as might be encountered in teleconferencing, motion may take on a wide variety of forms such as people moving on the set, data changing, punching, fading, or wiping from one scene to another, zooming, or panning. A single observer can at best develop a personalized, qualitative evaluation. However, a group of observers, comparing the relative performance of each codec against all other codecs can statistically develop a meaningful quantitative basis for ranking codec motion performance. The study performed by Delta Information Systems for DCA previously referenced performed exactly this function. A set of controlled motion scenes were recorded on high quality video tape. The signals from this tape was transmitted through a codec transmitter-receiver pair and the ouput again recorded on a high quality video tape recorder. Observers judged the relative motion performance of each codec against all other codecs in a strictly controlled environment and rated the performance of each pair evaluated using the CCIR developed rating system. The results were processed and an overall performance rating developed for each codec. The reader is referred to that study as a supplement to the data included in the responses and tabulated in this report.

Motion can be defined in several ways. First, motion is the ability to convey gradual changes as a result of movement within the scene, panning, zooming, and wiping. Secondly, motion can consist of abrupt scene changes such as a total change in a data display or in a punch between two scenes. The vendors were requested to supply information regarding the gradual scene changes for various degrees of change and also for a complete abrupt change. This will be summarized below. The second type of change can be quantitatively measured by determining the length of the time interval required to complete the change to some agreed upon point. There is presently no agreed upon standard for this measurement.

The questionnaire asked the vendor specific questions regarding the performance of the codec with various number of pixels changing between frames. The rates of change chosen were: Condition 1 = 10%, Condition 2 = 25%, Condition 3 = 50%, and Condition 4 = 100% (complete abrupt change).

3.9.1 CONDITION 1 (10% change)

The responses indicate that there is no effect on the quality of the display due to motion except that one vendor identified a loss of resolution in the area of the picture containing motion.

3.9.2 CONDITION 2 (25% change)

Two vendors again state that there is no effect on the quality of the display due to motion. Three vendors indicate that artifacts or jerkiness and a decrease of resolution in the motion area are apparent in the picture at this rate of change.

3.9.3 CONDITION 3 (50% change)

The same three vendors indicate that there is an effect in the picture due to pixel changes and that the effect is more pronounced than above. One vendor states that flicker is observable in the motion area while another says that the motion area is subject to distortion. All but one vendor responded that the motion areas suffer a loss of resolution, one adding that the loss of resolution extends to the static area.

3.9.4 CONDITION 4 (100% change)

The vendors of five out of the seven codecs indicate that there is an effect in the picture due to motion. Three state that flicker effects are observable for four of the seven codecs. Four vendors responded that distortion is apparent in moving objects. All but 1 vendors' codecs suffer from resolution degradation in the motion area and one in the static area.

# 4.0 RECOMMENDED EFFORTS TOWARD PROPOSING CODEC STANDARDS

## 4.1 DISCUSSION

The data contained in this report describes the state of the art of motion codecs operating at a transmission data rate of 1.5 Mb/s. It must be obvious to the reader that, while the codecs are quite sophisticated, the state of the art of specifying the performance of these codecs and the measurement of their performance is at a rather early stage of development. This is particularly true in the area of motion performance. The potential for this class of video transmission is so large that further effort toward developing codec standards is not only warranted but actually essential. This is true based on the few codecs which presently exist. In fact, it is necessary in consideration of the fact that new codecs will be introduced, that compression algorithms will be improved, other transmission data rates may become popular, and new teleconferencing requirements will come into vogue such as high resolution while the method of specifying their performance is inadequate.

In order to provide a meaningfull data base from which to draw in order to develop standards for television codecs, it is essential to continue to evaluate the performance of these improved products and, perhaps even more important, to develop standardized methods of specifying that performance. Additional testing of these parameters in a controlled environment will be required. To this end it is proposed that a test bed be established in which the codecs can be evaluated and performance standards for the various parameters can be established.

## 4.2 CONTINUING MOTION CODEC STUDY AND ANALYSIS

As mentioned above, there are several existing and anticipated features of motion codecs which should be subjected to the same type of analysis as the 1.5 Mb/s motion codecs have received in this report.

### 4.2.1 NEW CODECS

Among these features are new codecs. As the state-of-the-art of the hardware with which the codecs are implemented advances, new models will emerge requiring less power, providing improved performance, physically smaller in size, etc. A/D and D/A conversion, signal filtering and so on could quite likely be improved as a result.

#### 4.2.2 IMPROVED ALGORITHMS

New codecs could very well be developed as a result of new compression algorithms or as a result of improvements in existing algorithms. This is not at all unlikely when the strides made by the vendors in the past few years in reducing theoretical concepts to practical hardware implementations are considered.

#### 4.2.3 ADDITIONAL DATA RATES

One feature which should be studied and reported upon is already available from several codec vendors. That feature is operation at data rates other than 1.5 Mb/s. The range of these data rates for color motion codecs extends down to as low as 56 Kb/s. Motion performance at these data rates is an interesting subject for study, analysis, and evaluation.

#### 4.2.4 HIGH DEFINITION CODECS

Another trend which is becoming very popular is high definition TV. It is quite likely that this feature will also be incorporated into codecs in the near future. The relative performance of the various parameters of a high definition codec should be evaluated. For example, as the resolution increase, what is the effect on motion performance and on other picture parameters.

### 4.3 DEVELOPMENT OF STANDARD MEASUREMENT TECHNIQUES FOR CODEC PARAMETERS

One of the major contributions of this report is the detailed responses to a set of questions which were designed to thoroughly investigate the capabilities of the codecs. These responses should be a great aid to the reader in determining the relative features of the various codecs and to determine the state-of-the-art of 1.5 Mb/s color motion codecs. The responses are entirely those of the vendors; from their point of view. There are no standard measurement techniques for some of the parameters such as motion performance which the vendors could use so that the responses would be in unambiguous terms which had the same precise conotation for all readers. There are also no 1.5Mb/s performance standards to which the responses could be compared. In this report comparisons were made to standards of performance related to standard television systems in order to establish some common ground for comparison.

If standards are to be developed for television codecs, it appears to be essential that measurement techniques for the various codec parameters be developed and that the data obtained from these measurement be meaningful to the user in terms of picture quality. An initial approach to the resolution of this problem may be a twofold effort.

1) Development of measurement techniques.

2) Relating the measurements obtained to the results of subjective evaluations.

In general terms this approach consists of determining the parameters of the codec output pictures to be measured. Much of that effort has been done in developing the standards which now exist for conventional television systems. To these must be added the parameters which are either unique to motion codecs or which are greatly affected by the reduced data rate. A good example is motion portrayal. Having determined the parameters to be incorporated into a standard, the range of each of these parameters should be determined together with latitude for future improvement. At this point developing a measurement technique is possible.

The measurement technique will provide a set of absolute values which can be used to specify performance. However, in order to understand the meaning of these absolute values it is important to relate them to picture quality. This can be done by the classical method of having unbiased juries evaluate the quality of carefully selected pictures or sequences of pictures for which the absolute parameter values have been carefully measured. It is only then that parameter values can be used to meaningfully compare codecs and eventually to be establiished as a standard for motion codecs.

This discussion is extremely brief for a subject as complex as the development of measurement techniques for motion codec parameters. It is intended to show the need for such measurements in general, and as a prerequisite for the establishment of standards, and to point out at least one approach toward achieving that goal.

## 4.4 PERFORM CODEC TESTING AND EVALUATION

This function has been quite successfully provided by Delta Information Systems for 1.5 Mb/s color motion codecs as described previously in this report. The purpose of the test is to evaluate the relative performance of a number of similar codecs by means of large jury subjective evaluation, processing the resultant data, and converting the results into relative performance ratings. In the specific tests cited, the immediate goal was to determine the relative motion capability and the results were quite meaningful. The same test can be performed for other system parameters such as resolution, color performance, etc., at 1.5 Mb/s as well as at other data rates. The data thus generated will provide a very valuable set of codec performance data. This data, together with the result of the objective measurements suggested in the preceding section for the same test pictures can eventually lead to the correlation between objective data and the subjectively derived picture quality required to develop standards for codec performance.

## 4.5 ESTABLISH A MOTION CODEC TEST BED

Experience with the tests cited and with a large number of previous tests to perform picture quality assessment has left no doubt that in order to develop reliable data, it is essential to perform the tests and the jury evaluations in a highly controlled environment. This will eliminate, for example, technical compromises in the quality of the video signal used as the test video because the same tape and tape player/recorder can be used (among many other technical variables). It permits an ideal and identically controlled environment for all jury evaluations. A test bed of this type further removes the test from extraneous influences.

The combination of the preceding recommendations; namely, continuing codec study and evaluation, development of standard measurement techniques for codec parameters, performing codec testing and evaluation, and establishment of a codec test bed is the proper approach to establishing the data needed to eventually generate a set of codec performance standards. It has an immediate added benefit that the range of codec capability within various categories is ascertained and published and the codec performance, one with respect to the other, can be ranked as an aid to system designers and users.

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